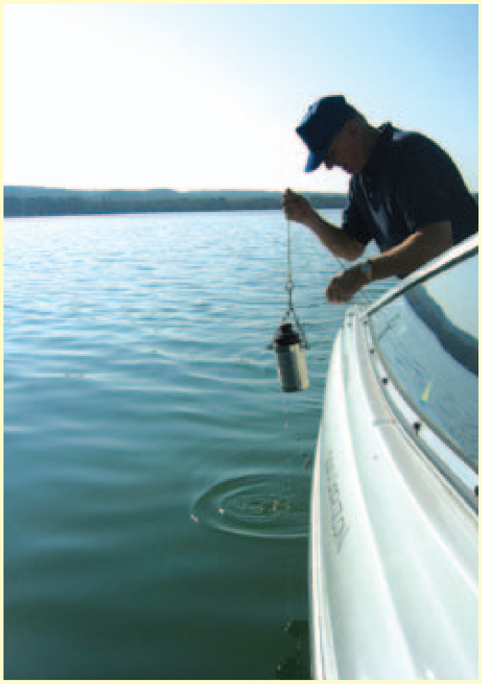
HIGHLIGHT

Volunteer Power: Monitoring Lakes with Volunteers

Hundreds of organizations monitor lakes in the U.S. using trained volunteers. Some volunteer groups are run by state environmental agencies. Others are managed by local residential lake associations determined to protect the quality of their local lake, pond or reservoir. Universities, often as part of U.S. Department of Agriculture Cooperative Extension, manage a number of statewide lake volunteer monitoring programs. In some states, trained volunteers are the leading source of consistent, long-term lake data. Volunteer-collected lake data are widely used in state water quality assessment reports, identification of impaired waters, local decision making, and scientific study.



A volunteer with the Michigan Cooperative Lakes Monitoring Program collects a water sample for chlorophyll analysis.
Photo courtesy of Ralph Bednarz.

One national program designed to promote the use of volunteers in lake monitoring is the Secchi Dip-In (http://dipin.kent.edu/index.htm). Run by limnologist Dr. Robert Carlson of Kent State University since 1994, the Dip-In encourages individuals who are members of a volunteer monitoring program to measure lake transparency on or around the 4th of July and report their results on a national website. These values are used to assess the transparency of volunteer-monitored waters in the U.S. and Canada. One goal of the Dip-In is to increase the number and interest of volunteers in environmental monitoring and to provide national level recognition of the work that they perform.

Volunteer Monitoring and the National Lakes Assessment

The relationship between lake volunteer monitoring and the National Lakes Assessment (NLA) is in its earliest stages. However, volunteers did participate in a few states where links between volunteer programs and state monitoring staff were strong. The Vermont Department of Environmental Conservation (DEC) conducted its own statistically valid assessment of 50 lakes including NLA-selected lakes, about half of which are also routinely sampled by volunteers in the DEC-managed Vermont Lay Monitoring Program. Volunteers were informed ahead of time when NLA sampling crews were going to arrive, and in some cases were able to provide boats for the crews as well as welcome local advice regarding lake navigation and access. In Rhode Island, some volunteers conducted side-by-side sampling with the NLA crews for later analysis and comparison using Rhode Island Watershed Watch methods. Volunteers observed the sampling, assisted crews with equipment, provided firsthand knowledge of local lakes, and contacted news media to provide publicity. In Michigan, at two lakes also monitored by Michigan's Cooperative Lake Monitoring Program, volunteers sampled side-by-side with Michigan Department of Environmental Quality staff and NLA survey crews. Local newspaper reporters observed these monitoring events and provided press coverage of the volunteers working alongside the survey crews.

Volunteer monitors are important partners in the assessment and protection of the nation's lakes, and state agencies and EPA should continue to explore pathways for improved communication and cooperation with volunteer programs in future surveys of the nation's lakes.

CHAPTER 6.

ECOREGIONAL RESULTS

Photo courtesy of Tetra Tech

IN THIS CHAPTER

- Nationwide Comparisons
- Northern Appalachians
- Southern Appalachians
- Coastal Plains
- Upper Midwest
- Temperate Plains
- Southern Plains
- Northern Plains
- Western Mountains
- Xeric

Chapter 6
Ecoregional Results

Taken individually, each lake is a reflection of its watershed. The characteristics of the watershed, *i.e.*, its size relative to the lake, topography, geology, soil type, land cover, and human activities, together influence the amount and nature of material entering the lake. For example, a deep alpine lake located in a Rocky Mountain watershed will likely have clear, pristine water and little biological productivity. Conversely, a lake in a coastal plains watershed of the mid-Atlantic region, an area of nutrient-rich alluvial soils and a long history of human settlement, will more likely be characterized by high turbidity, high concentrations of nutrients and organic matter, prevalent algal blooms, and abundant aquatic weeds and other plants. Atmospheric deposition of airborne pollutants, as well as nutrients traveling in groundwater from hundreds of miles away, can affect the watershed and influence the lake condition.

Lakes in high population areas are especially vulnerable. Combined sewer overflow and stormwater runoff can carry marked amounts of pollutants such as metals, excess sediment, bacteria, and most recently, pharmaceuticals. As a result, expectations and lake condition vary across the country.

Because of the diversity in landscape, it is important to assess waterbodies in their own geographical setting. The NLA was designed to report findings on an ecoregional scale. Ecoregions are areas that contain similar environmental characteristics and are defined by common natural characteristics such as climate, vegetation, soil type, and geology. By looking at lake conditions in these smaller ecoregions, decision-makers can begin to understand patterns based on landform and geography, and whether the problems are isolated in one or two adjacent regions or are widespread.

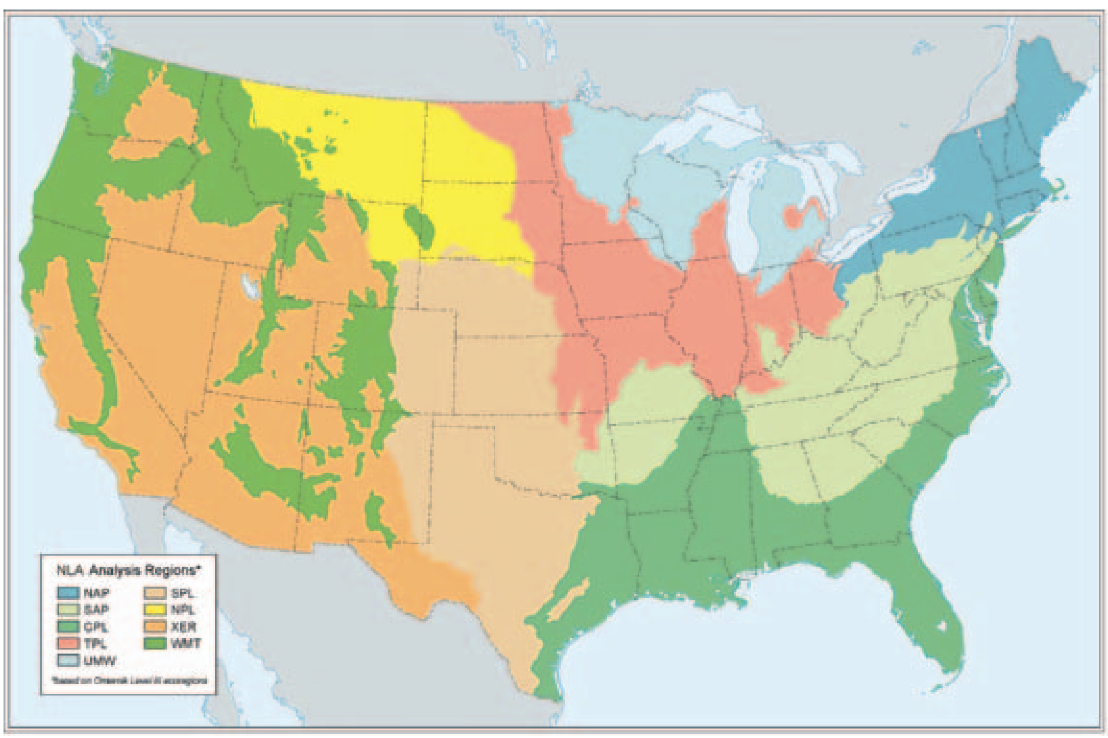


Figure 20. Ecoregions used as part of the National Lakes Assessment.

EPA has defined ecoregions at various scales, ranging from coarse ecoregions at the continental scale (Level I) to finer ecoregions that divide the land into smaller units (Level III or IV). The nine ecoregions used in this assessment are aggregations of the Level III ecoregions delineated by EPA for the continental U.S. These nine ecoregions as shown in Figure 20 are:

- Northern Appalachians (NAP)
- Southern Appalachians (SAP)
- Coastal Plains (CPL)
- Upper Midwest (UMW)
- Temperate Plains (TPL)
- Southern Plains (SPL)
- Northern Plains (NPL)
- Western Mountains (WMT)
- Xeric (XER)

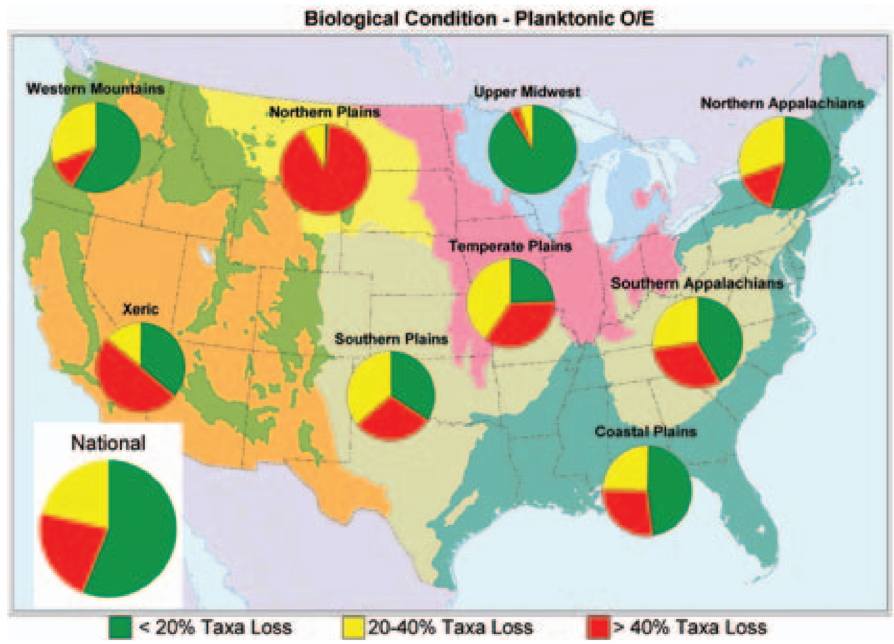


Figure 21. Biological condition (based on planktonic O/E taxa loss) across nine ecoregions.

To assess waters within each ecoregion, the NLA captures the geographic variation in lakes using regionally-specific reference conditions. The resulting set of reference lakes all share common characteristics and occur within a common geographic area.[5] This approach not only allows lakes in one region to be compared with the particular reference lakes of that region, but also allows for the comparison of one ecoregion to another. This means that lakes in the arid west are not being assessed against lakes in the Southern Plains. Yet, at the same time, this also means that if 10% of the Xeric west lakes were in poor condition and 20% of the Southern Plains lakes were relatively poor, one can compare the two ecoregions and say that the Southern Plains have twice the proportion of lakes in poor condition.

Nationwide Comparisons

Biological Condition – Taxa Loss

Regionally, the proportion of lakes with good biological condition ranges from 91% in the Upper Midwest to < 5% in the Northern Plains (Figure 21). In general, the glaciated and/or mountainous regions have the highest proportion of lakes exhibiting good biological condition, followed by Coastal Plains lakes. The Xeric west and Northern Plains exhibit the highest proportions of lakes in poor condition biologically. Forty nine percent of lakes are in poor biological condition in the Xeric region, while just under 85% of Northern Plains lakes are in poor biological condition.

[5] It is important to note that the geographic boundaries of the regionally-specific reference areas do not specifically match those of the nine ecoregions. More detailed information about how regional reference lakes were determined can be found in the Technical Report.

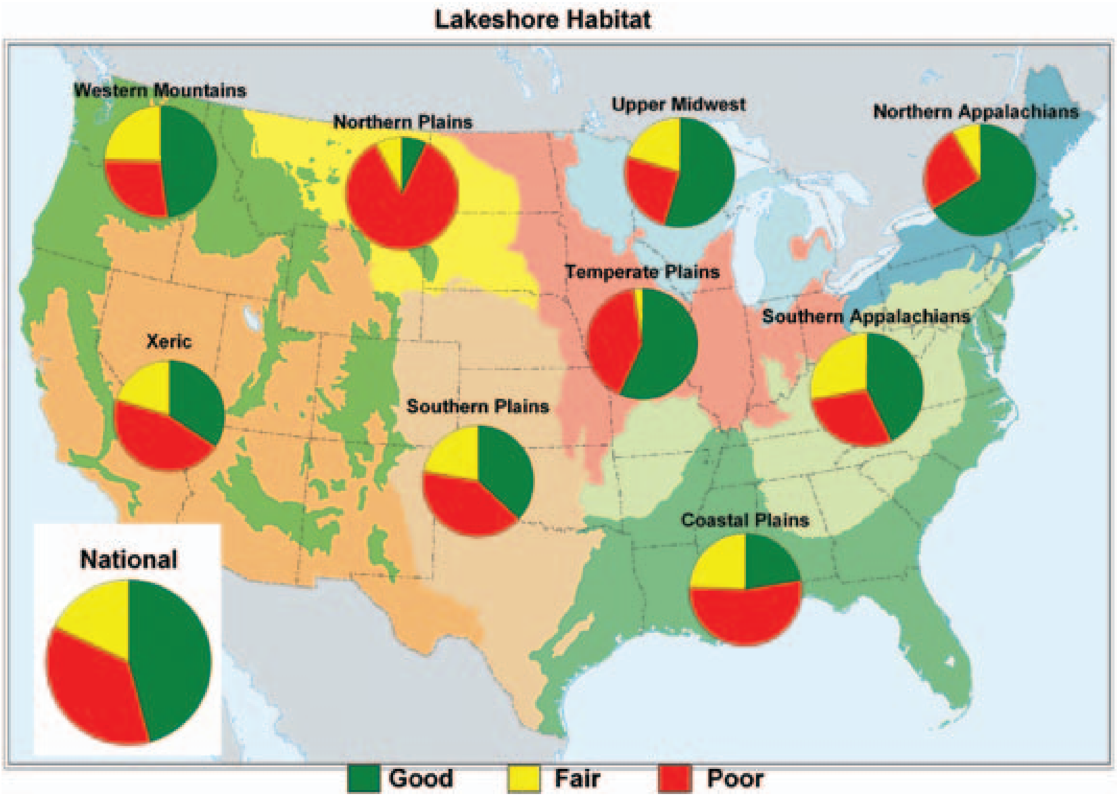


Figure 22. Habitat condition of the nation's lakes across nine ecoregions based on lakeshore habitat.

Habitat Stressors – Lakeshore Habitat

In the NLA, habitat stress was assessed using four indicators: lakeshore habitat, shallow water habitat, physical habitat complexity and human disturbance. Of these, the most revealing indicator, based on the relative and attributable risk analyses, is lakeshore habitat. This analysis indicates that biological integrity of lakes is three times more likely to be poor when the lakeshore habitat area is classified as poor. Regionally, the proportion of lakes with poor lakeshore habitat ranges from a low of 25% in the Northern Appalachians to a high of 84% in the Northern Plains (Figure 22). Poor lakeshore habitat is most prevalent in the Plains and Xeric ecoregions.

Trophic Status

Regionally, the proportion of lakes classified as oligotrophic, based on measures of chlorophyll-*a*, ranges from 54% in the Western Mountains to < 5% in the Temperate Plains (Figure 23). The highest proportion of mesotrophic waters are found in the Northern and Southern Appalachians, and the Upper Midwest. The proportion of eutrophic lakes is highest in the Coastal and Southern Plains. Hypereutrophic lakes are most prevalent in the Temperate Plains, where nearly 50% of lakes are classified hypereutrophic.

Recreational Suitability – Cyanobacteria (blue-green algae)

Over 75% of lakes in the Western Mountains, Xeric west, Upper Midwest, and Northern and Southern Appalachians pose minimal risk of exposure to cyanobacteria-produced toxins. The greatest proportions of lakes at high exposure risk (> 100,000 cells/L) occur in the Southern, Coastal, and Temperate Plains. The Northern Plains have over 50% of lakes in the moderate exposure risk category (Figure 24).

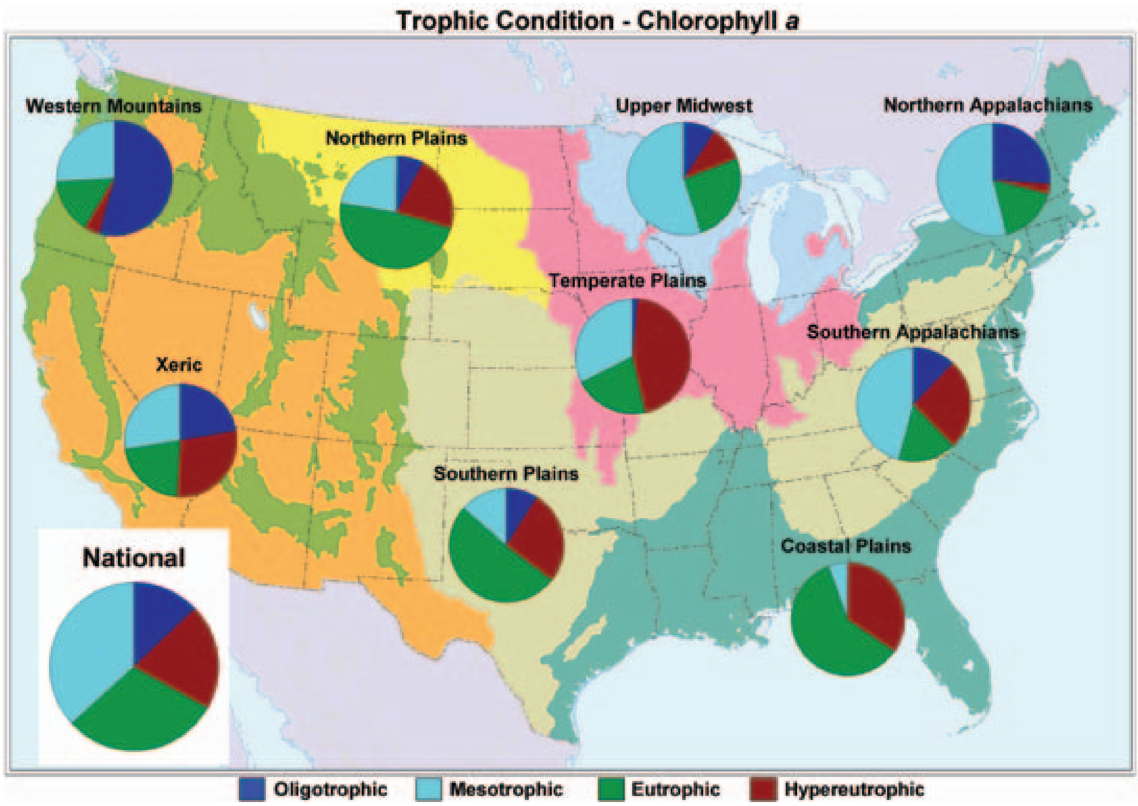


Figure 23. Trophic state across nine ecoregions (based on chlorophyll-*a.)*

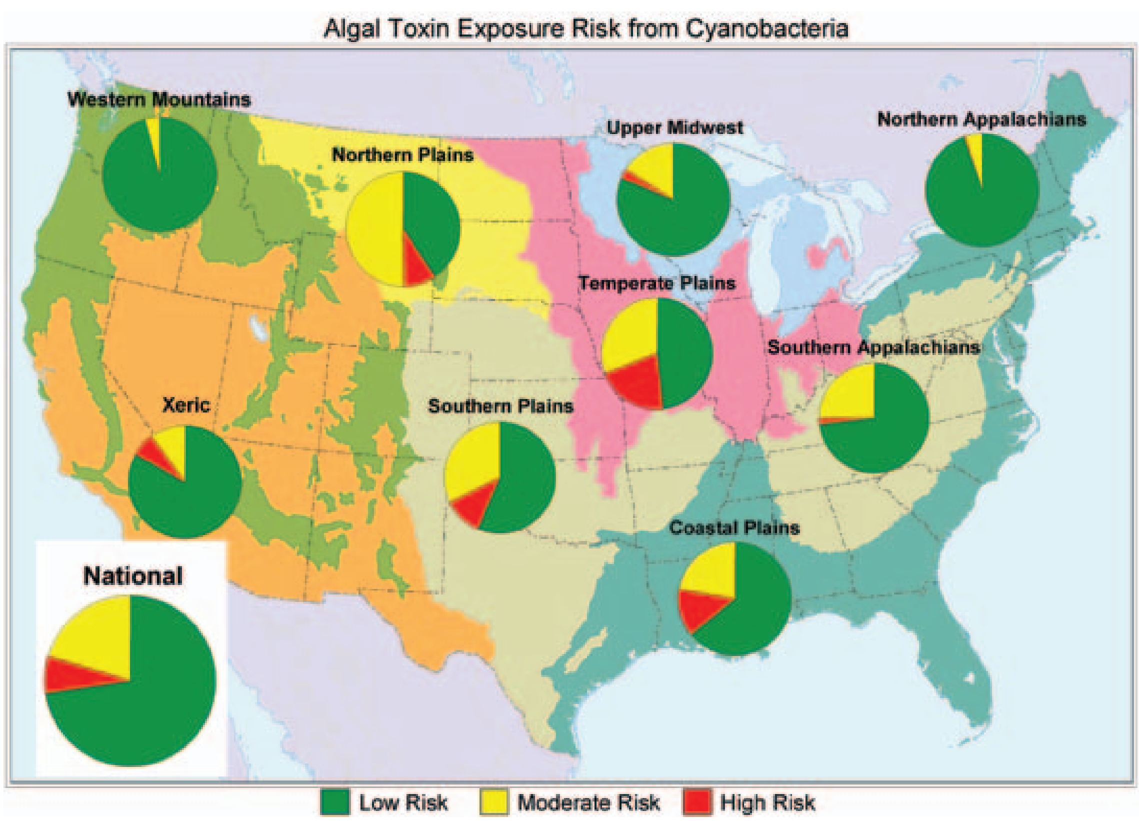


Figure 24. Comparison of exposure to cyanobacteria risk across nine ecoregions.

Northern Appalachians
The Landscape

The Northern Appalachians ecoregion covers all of the New England states, most of New York, the northern half of Pennsylvania, and northeast Ohio. It encompasses New York's Adirondack and Catskill Mountains and Pennsylvania's mid-northern tier, including the Allegheny National Forest. Major waterbodies include Lakes Ontario and Erie, New York's Finger Lakes, and Lake Champlain. There are 5,226 lakes in the Northern Appalachians that are represented by the NLA, 54% of which are constructed reservoirs. The ecoregion comprises some 139,424 square miles (4.6% of the United States), with about 4,722 square miles (3.4%) under federal ownership. Based on satellite images in the National Land Cover Dataset (1992), the distribution of land cover is 69% forested and 17% planted/ cultivated, with the remaining 14% of land in other types of cover.

Many lakes in the region were created for the purpose of powering sawmills. During the 18th and early 19th centuries, lakes were affected by sedimentation caused by logging, farming, and damming of waterways. When agriculture moved west and much of eastern farmland converted back into woodlands, sediment yields declined in some areas. In many instances, lakes in what appears to be pristine forested settings are in fact still recovering from prior land use disturbances. In the mountainous regions of the Northern Appalachian ecoregion, many large reservoirs were constructed throughout the early 20th century for hydropower generation and/or flood control.

Dick's Pond in Massachusetts.
Photo courtesy of USEPA Region 1.

Findings

A total of 93 of the selected NLA sites were sampled during the summer of 2007 to characterize the condition of lakes throughout the ecoregion. An overview of the NLA findings for Northern Appalachian lakes is shown in Figure 25.

Biological Condition

Fifty-five percent of lakes are in good biological condition based on planktonic O/E, and when using the diatom IBI, 67% of lakes in the ecoregion are in good biological condition relative to reference condition. Conversely, the percentages of lakes in poor condition are 15% and 10% based on the two analyses, respectively.

Trophic Status

Based on chlorophyll-*a*, 26% of lakes are oligotrophic, 54% are mesotrophic, 17% are eutrophic, and only 3% are considered hypereutrophic.

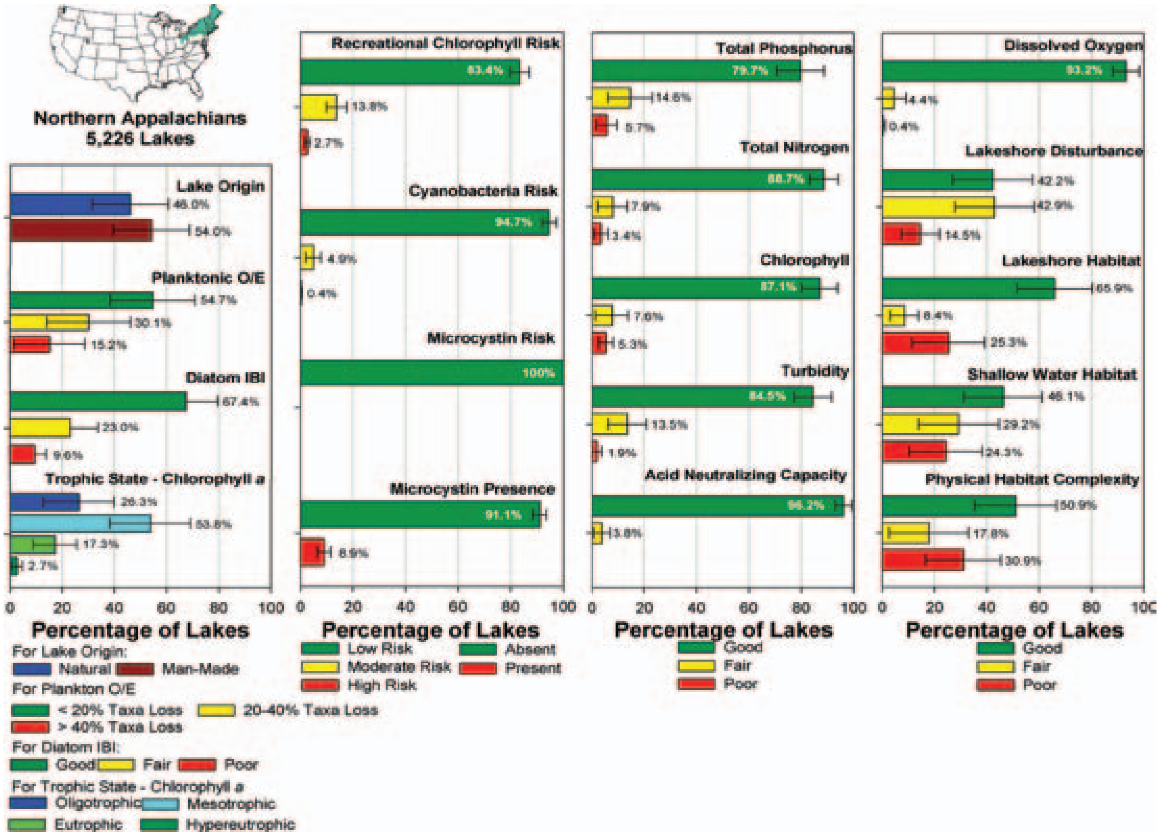


Figure 25. NLA results for the Northern Appalachians. Bars show the percentage of lakes within a condition class for a given indicator. For Recreational Chlorophyll risk and Cyanobacteria risk, the percentage numbers indicate the risk of exposure to algal toxins associated with the presence of cholorphyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

Recreational Suitability

Using the indicators and World Health Organization guidelines described in Chapter 3, most lakes in the Northern Appalachian ecoregion exhibit relatively low risk of exposure to cyanobacteria and associated cyanotoxins. Based on cyanobacterial counts, 95% of lakes exhibit low exposure risk. Microcystin was present in 9% of lakes.

Physical Habitat Stressors

Lakeshore habitat is considered good in 66% of the lakes in this ecoregion. Given the long history of land use and settlement in this ecoregion, the shorelines of Northern Appalachian lakes exhibit relatively disturbed conditions due to human activities. Fifty-seven percent of lakes show moderate to high levels of lakeshore disturbance.

Chemical Stressors

In contrast to physical habitat conditions, the majority of Northern Appalachian lakes exhibit high-quality waters based on the NLA chemical stressor indicators. Relative to regionally-specific reference expectations, total phosphorus and nitrogen, chlorophyll-*a*, and turbidity levels are considered good in 80% or more of lakes in this ecoregion. Lakes are in good condition based on ANC and surface water DO levels when compared to nationally-consistent thresholds.

Southern Appalachians
The Landscape

The Southern Appalachians ecoregion stretches over 10 states, from northeastern Alabama to central Pennsylvania. Also included in this region are the interior highlands of the Ozark Plateau and the Ouachita Mountains in Arkansas, Missouri, and Oklahoma. The region covers about 321,900 square miles (10.7% of the United States) with about 42,210 square miles (10.7%) under federal ownership. Many important public lands such as the Great Smoky Mountains National Park and surrounding national forests, the Delaware Water Gap National Recreation Area, the George Washington and Monongahela National Forests, and the Shenandoah National Park are located within the region. Topography is mostly hills and low mountains with some wide valleys and irregular plains. Piedmont areas are included within the Southern Appalachians ecoregion.

Natural lakes are nearly non-existent in this ecoregion. The 4,690 lakes in the Southern Appalachians ecoregion represented by the NLA are all man-made. The configuration of the Southern Appalachian valleys has proven ideal for the construction of man-made lakes, and some of the nation's largest hydro-power developments can be found in the Tennessee Valley.

Findings

A total of 116 of the selected NLA sites were sampled during the summer of 2007 to characterize the condition of lakes throughout the ecoregion. An overview of the NLA findings for lakes in the Southern Appalachians is shown in Figure 26.

Pennsylvania lake.
Photo courtesy of Frank Borsuk.

Biological Condition

Forty-two percent of lakes are in good biological condition based on planktonic O/E and when using the diatom IBI, 63% of lakes in the ecoregion are in good biological condition relative to reference condition. Conversely, the percentages of lakes in poor condition are 31% and 13% based on the two analyses, respectively. The apparent difference between these two biological indices may suggest that the two indicators are responding to different stressors in lakes in this particular ecoregion.

Trophic Status

Based on chlorophyll-*a*, 12% of lakes are oligotrophic, 46% are mesotrophic, 17% are eutrophic, and 26% are considered hypereutrophic.

Recreational Suitability

While many lakes in the Southern Appalachians ecoregion exhibit relatively low risk of exposure to cyanobacteria and associated cyanotoxins, a quarter of lakes exhibit moderate risk levels based on chlorophyll-*a* and cyanobacteria values. Microcystin was present in 25% of lakes.

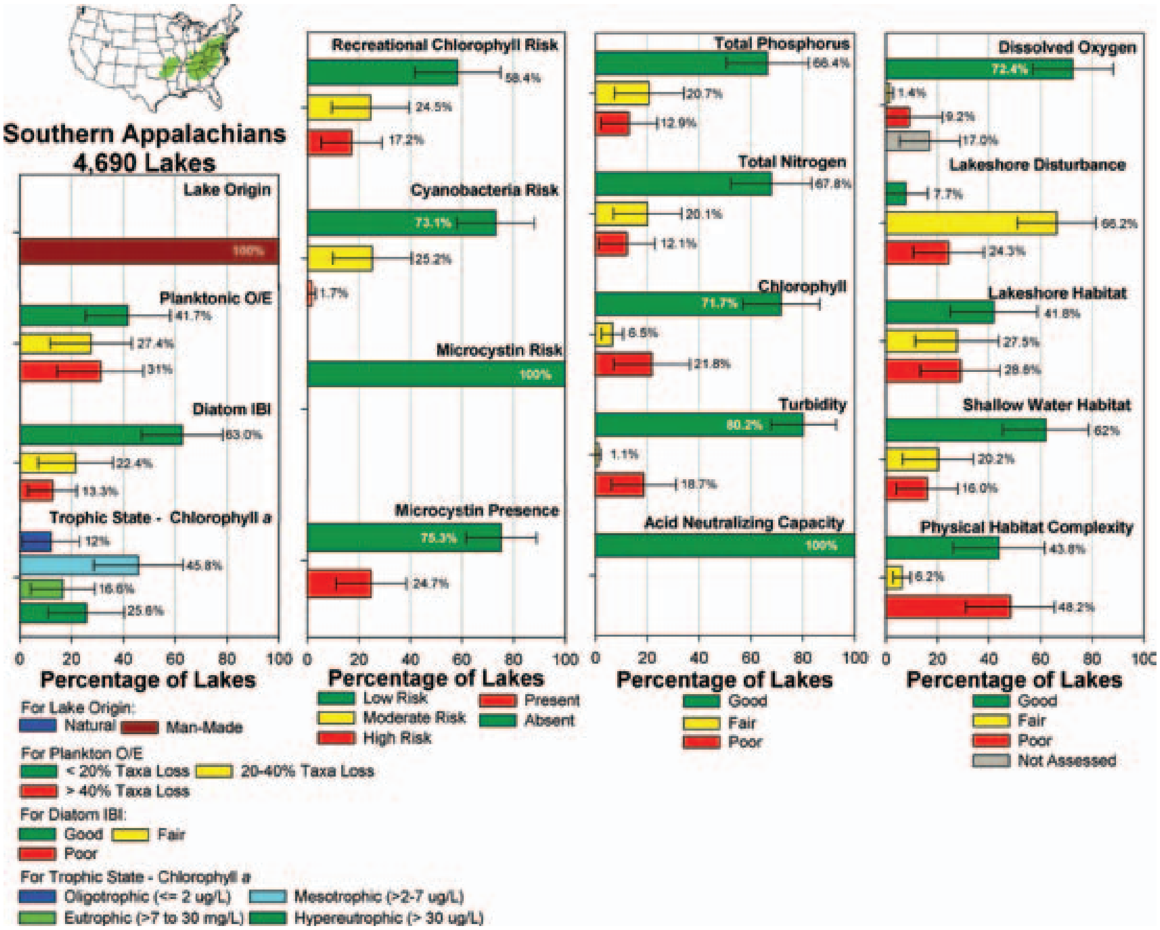


Figure 26. NLA results for the Southern Appalachians. Bars show the percentage of lakes within a condition class for a given indicator. For Recreational Chlorophyll risk and Cyanobacteria risk, the percentage numbers indicate the risk of exposure to algal toxins associated with the presence of cholorphyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

Physical Habitat Stressors

Lakeshore habitat is considered good in 42% of the lakes in this ecoregion. Yet the shorelines of Southern Appalachians lakes indicate considerable lakeshore development pressure. Over 90% of lakes show moderate to high levels of lakeshore disturbance.

Chemical Stressors

Based on the NLA chemical stressor indicators, a considerable proportion of Southern Appalachians lakes exhibit good quality waters. Total phosphorus and nitrogen are considered good in 66% and 68% of lakes, respectively. Relative to regionally-specific reference expectations, chlorophyll-*a* and turbidity levels are considered good in 72% or more of the man-made lakes in this ecoregion. Man-made lakes are in good condition based on ANC and surface water DO levels when compared to nationally consistent thresholds, although 9% of lakes were ranked poor due to low dissolved oxygen.

Coastal Plains

The Landscape

The Coastal Plains ecoregion covers the Mississippi Delta and Gulf Coast, north along the Mississippi River to the Ohio River, all of Florida, eastern Texas, and the Atlantic seaboard from Florida to New Jersey. Total area is about 395,000 square miles (13% of the United States) with 25,890 square miles (6.6%) under federal ownership. Based on satellite images in the 1992 National Land Cover Dataset, the distribution of land cover is 39% forested, 30% planted/cultivated, and 16% wetlands, with the remaining 15% of land in other types of cover. Damming, impounding, and channelization in this ecoregion have altered the rate and timing of water flow and delivery to lakes.

A subset of major lakes of the region includes the Toledo Bend (TX) and Sam Rayburn Reservoirs (TX/LA), Lake Okeechobee (FL), Lake Marion (SC), and the massive lake-wetland complexes north of the Gulf Coast. The Coastal Plains is also home to a variety of lakes and ponds, such as Cape Cod kettleholes, New Jersey Pine Barren ponds, southeastern blackwater lakes, Carolina "Bays," and the limestone-rich clear lakes of the Florida peninsula. A total of 7,009 lakes and reservoirs in the Coastal Plains ecoregion are represented in the NLA, and 69% of these are man-made.

Findings

A total of 102 of the selected NLA sites were sampled during the summer of 2007 to characterize the condition of lakes throughout the ecoregion. An overview of the NLA findings for the Coastal Plains lakes is shown in Figure 27.

Biological Condition

Forty-seven percent of lakes are in good biological condition based on planktonic O/E, and when using the diatom IBI, 57% of lakes in the ecoregion are in good biological condition relative to reference condition. Conversely, the percentages of lakes in poor condition are 27% and 6% based on the two analyses, respectively

Trophic Status

Based on chlorophyll-*a*, 6% of the lakes are mesotrophic, 60% are eutrophic, and 34% are considered hypereutrophic.

Recreational Suitability

Lakes in the Coastal Plains ecoregion exhibit moderate risk of exposure to cyanobacteria and associated cyanotoxins. Based on cyanobacterial counts, 64% of lakes exhibited low exposure risk. Microcystin was present in 35% of lakes.

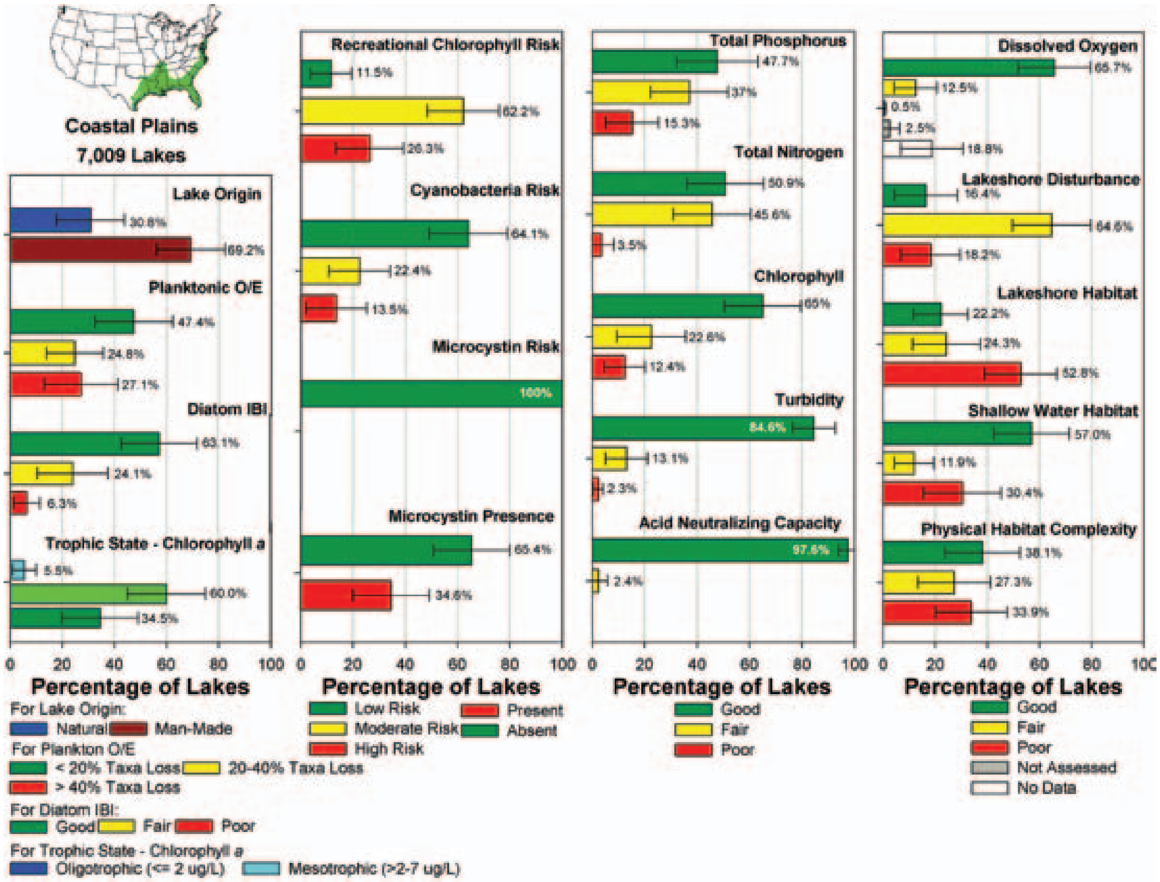


Figure 27. NLA findings for the Coastal Plains. Bars show the percentage of lakes within a condition class for a given indicator. For Recreational Chlorophyll risk and Cyanobacteria risk, the percentage numbers indicate the risk of exposure to algal toxins associated with the presence of cholorphyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

Physical Habitat Stressors

Lakeshore habitat is considered good in 22% of the lakes in this ecoregion. Moreover, the shorelines of the Coastal Plains lakes are highly disturbed, indicating considerable lakeshore development pressure in this region. About 84% of lakes show moderate to high levels of lakeshore human disturbance.

Chemical Stressors

Based on the NLA chemical stressor indicators, water quality is somewhat variable across the Coastal Plains. Total phosphorus and nitrogen are considered good in 48% and 51% of lakes, respectively, and are poor in 15% and 4% of lakes, respectively. Relative to regionally-specific reference expectations, chlorophyll-*a* concentrations are considered good in 65% of lakes, and turbidity levels are considered good in 85% of lakes in this ecoregion. Lakes are in good condition based on ANC and surface water DO levels when compared to nationally-consistent thresholds, although 13% of lakes were ranked fair due to low dissolved oxygen.

Upper Midwest
The Landscape

The Upper Midwest ecoregion covers most of the northern half and southeastern part of Minnesota, two-thirds of Wisconsin, and almost all of Michigan, extending about 160,374 square miles (5.4% of the United States). A total of 15,562 lakes in the ecoregion are represented in the NLA, nearly all of which are of natural origin, reflecting the glaciation history of this region. Sandy soils dominate with relatively high water quality in lakes supporting warm and cold-water fish communities. Major lakes of the region include the Great Lakes (which, for design considerations, were not represented by the NLA), and also Lake of the Woods and Red Lake (MN). The glaciated terrain of this ecoregion is typically plains with some hill formations. The northern tier of this ecoregion has a very high number of smaller lakes, both drainage and seepage, which range widely in geochemical makeup. Much of the land is covered by national and state forest. Federal lands account for 15.5% of the area at about 25,000 square miles. Based on satellite images in the 1992 National Land Cover Dataset, the distribution of land cover is 40% forested, 34% planted/cultivated, and 17% wetlands, with the remaining 9% of land in other types of cover. Most of the landscape was influenced by early logging and agricultural activities.

Findings

A total of 148 of the selected NLA sites were sampled during the summer of 2007 to characterize the condition of lakes throughout the ecoregion. An overview of the NLA findings for the Upper Midwest lakes is shown in Figure 28.

Minnesota prairie pothole lake.
Photo courtesy of Steve Heiskary.

Biological Condition

Ninety-one percent of lakes are in good biological condition based on planktonic O/E, and when using the diatom IBI, 47% of lakes in the ecoregion are in good biological condition relative to reference condition. Conversely, the percentages of lakes in poor condition are 4% and 22% based on the two analyses, respectively. The difference between these two biological indices may suggest that the two indicators are responding to different stressors in lakes in this particular ecoregion.

Trophic Status

Based on chlorophyll-*a*, 9% of lakes are oligotrophic, 54% are mesotrophic, 26% are eutrophic, and 10% are considered hypereutrophic.

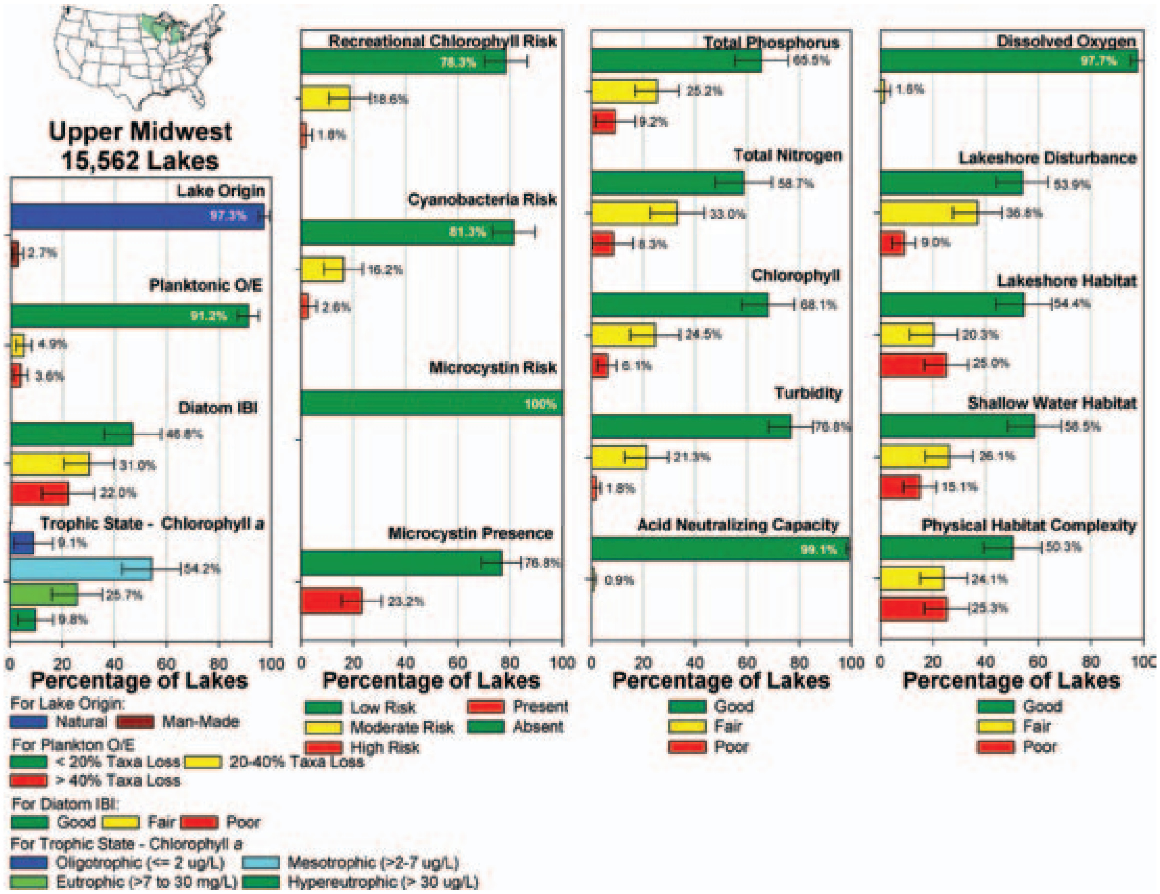


Figure 28. NLA findings for the Upper Midwest. Bars show the percentage of lakes within a condition class for a given indicator. For Recreational Chlorophyll risk and Cyanobacteria risk, the percentage numbers indicate the risk of exposure to algal toxins associated with the presence of cholorphyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

Recreational Suitability

Lakes in the Upper Midwest exhibit relatively low risk of exposure to cyanobacteria and associated cyanotoxins. Based on cyanobacterial counts, 81% of lakes exhibited low exposure risk. Microcystin was present in 23% of lakes.

Physical Habitat Stressors

Lakeshore habitat is considered good in 54% of the lakes in this ecoregion. The shorelines of the Upper Midwest lakes, indicate considerable lakeshore development pressure. Forty-six percent of lakes show moderate to high levels of lakeshore human disturbance.

Chemical Stressors

Based on the NLA chemical stressor indicators, water quality is relatively good across the Upper Midwest. Total phosphorus and nitrogen are considered good in 66% and 59% of lakes, respectively, and are poor in 9% and 8%, of lakes respectively. Relative to regionally-specific reference expectations, chlorophyll-a concentrations are considered good in 68% of lakes, and turbidity levels are considered good in 77% of lakes in this ecoregion. Lakes are in good condition based on ANC and surface water DO levels when compared to nationally-consistent thresholds.

Temperate Plains
The Landscape

The Temperate Plains ecoregion includes the open farmlands of Iowa; eastern North and South Dakota; western Minnesota; portions of Missouri, Kansas, and Nebraska; and the flat farmlands of western Ohio, central Indiana, Illinois, and southeastern Wisconsin. This ecoregion covers some 342,200 square miles (11.4% of the United States), with approximately 7,900 square miles (2.3%) in federal ownership. The terrain consists of smooth plains, numerous small lakes, prairie pothole lakes, and wetlands. A total of 6,327 lakes in the Temperate Plains ecoregion are represented in the NLA, of which 75% are of natural origin. Lakes of this region are generally small, with over 60% of lakes smaller than 100 hectares in size. Agriculture is the predominant land use. Based on satellite images in the 1992 National Land Cover Dataset, the distribution of land cover is 9% forested and 76% planted/cultivated, with the remaining 15% of land in other types of cover.

Sampling with a D-net for benthic macroinvertebrates.
Photo courtesy of Great Lakes Environmental Center.

Findings

A total of 137 of the selected NLA sites were sampled during the summer of 2007 to characterize the condition of lakes throughout this ecoregion. An overview of the NLA findings for the Temperate Plains lakes is shown in Figure 29.

Biological Condition

One quarter, or 24%, of lakes are in good biological condition based on planktonic O/E, and when using the diatom IBI, 17% of lakes in the ecoregion are in good biological condition relative to reference condition. Conversely, the percentages of lakes in poor condition are 35% and 52% based on the two analyses, respectively.

Trophic Status

Based on chlorophyll-*a*, 2% of lakes are oligotrophic, 32% are mesotrophic, 21% are eutrophic, and 45% are considered hypereutrophic.

Recreational Suitability

Lakes in the Temperate Plains exhibit moderate risk of exposure to cyanobacteria and associated cyanotoxins. Based on cyanobacterial counts, 48% of lakes exhibited low exposure risk. Microcystin was present in 67% of lakes.

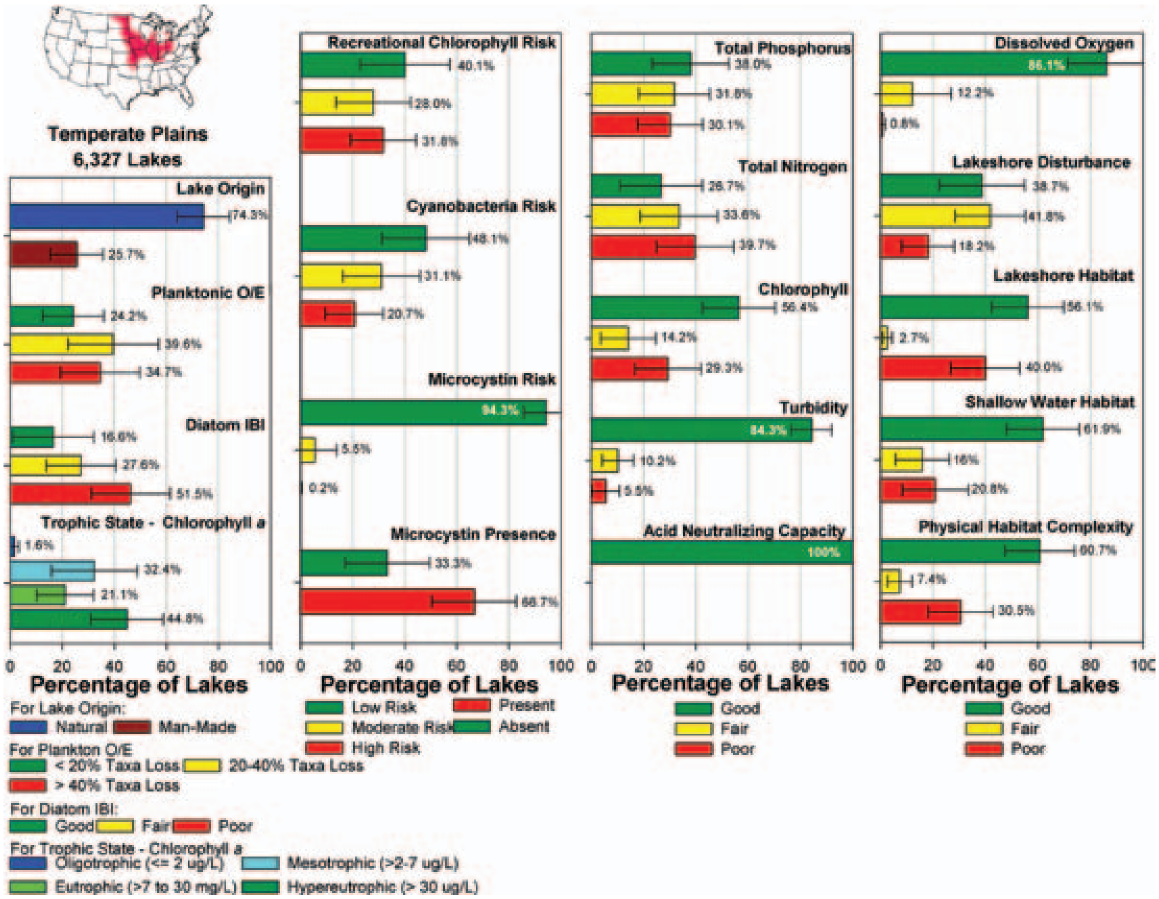


Figure 29. NLA findings for the Temperate Plains. Bars show the percentage of lakes within a condition class for a given indicator. For Recreational Chlorophyll risk and Cyanobacteria risk, the percentage numbers indicate the risk of exposure to algal toxins associated with the presence of cholorphyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

Physical Habitat Stressors

Lakeshore habitat is considered good in 56% of the lakes in this ecoregion. The shorelines of the Temperate Plains lakes exhibit human activity disturbances, urban development, and agricultural pressures in this region. Sixty percent of lakes show moderate to high levels of lakeshore human disturbance.

Chemical Stressors

Based on the NLA chemical stressor indicators, water quality in the Temperate Plains is somewhat variable. Total phosphorus and nitrogen are considered good in 38% and 27% of lakes, respectively, and are poor in 30% and 40% of lakes, respectively. Relative to regionally-specific reference expectations, chlorophyll-*a* concentrations are considered good in 56% of lakes, and turbidity levels are considered good in 84% of lakes in this ecoregion. Lakes are generally in good condition based on ANC and surface water DO levels when compared to nationally-consistent thresholds. However, dissolved oxygen is fair in 12% of lakes.

Southern Plains
The Landscape

The Southern Plains ecoregion covers approximately 405,000 square miles (13.5% of the United States) and includes central and northern Texas; most of western Kansas and Oklahoma; and portions of Nebraska, Colorado, and New Mexico. The terrain is a mix of smooth and irregular plains interspersed with tablelands and low hills. Most of the great Ogallala aquifer lies underneath this region.

Based on satellite images in the 1992 National Land Cover Dataset, the distribution of land cover is 45% grassland, 32% planted/cultivated, and 14% shrubland, with the remaining 9% of land in other types of cover. The Great Prairie grasslands, which once covered much of the Southern Plains region, are considered the most altered and endangered large ecosystem in the United States. About 90% of the original tall grass prairie has been replaced by other vegetation or land use. Federal land ownership in the region totals about 11,980 square miles or approximately 3% of the total, the lowest share of all NLA aggregate ecoregions. A total of 3,148 lakes in the Southern Plains ecoregion are represented in the NLA, 97% of which are constructed reservoirs.

Findings

A total of 128 of the selected NLA sites were sampled during the summer of 2007 to characterize the condition of lakes throughout this ecoregion. An overview of the NLA findings for the Southern Plains lakes is shown in Figure 30.

Comanche Creek Reservoir.
Photo courtesy of Texas Commission of Environmental Quality.

Biological Condition

Thirty-four percent of lakes are in good biological condition based on planktonic O/E, and when using the diatom IBI, 41% of lakes in the ecoregion are in good biological condition relative to reference condition. Conversely, the percentages of lakes in poor condition are 29% and 23% based on the two analyses, respectively.

Trophic Status

Based on chlorophyll-*a*, 9% of lakes are oligotrophic, 14% are mesotrophic, 51% are eutrophic, and 26% are considered hypereutrophic.

Recreational Suitability

Lakes in the Southern Plains exhibit moderate risk of exposure to cyanobacteria and associated cyanotoxins. Based on cyanobacterial counts, 57% of lakes exhibit low exposure risk. Microcystin was present in 21% of lakes.

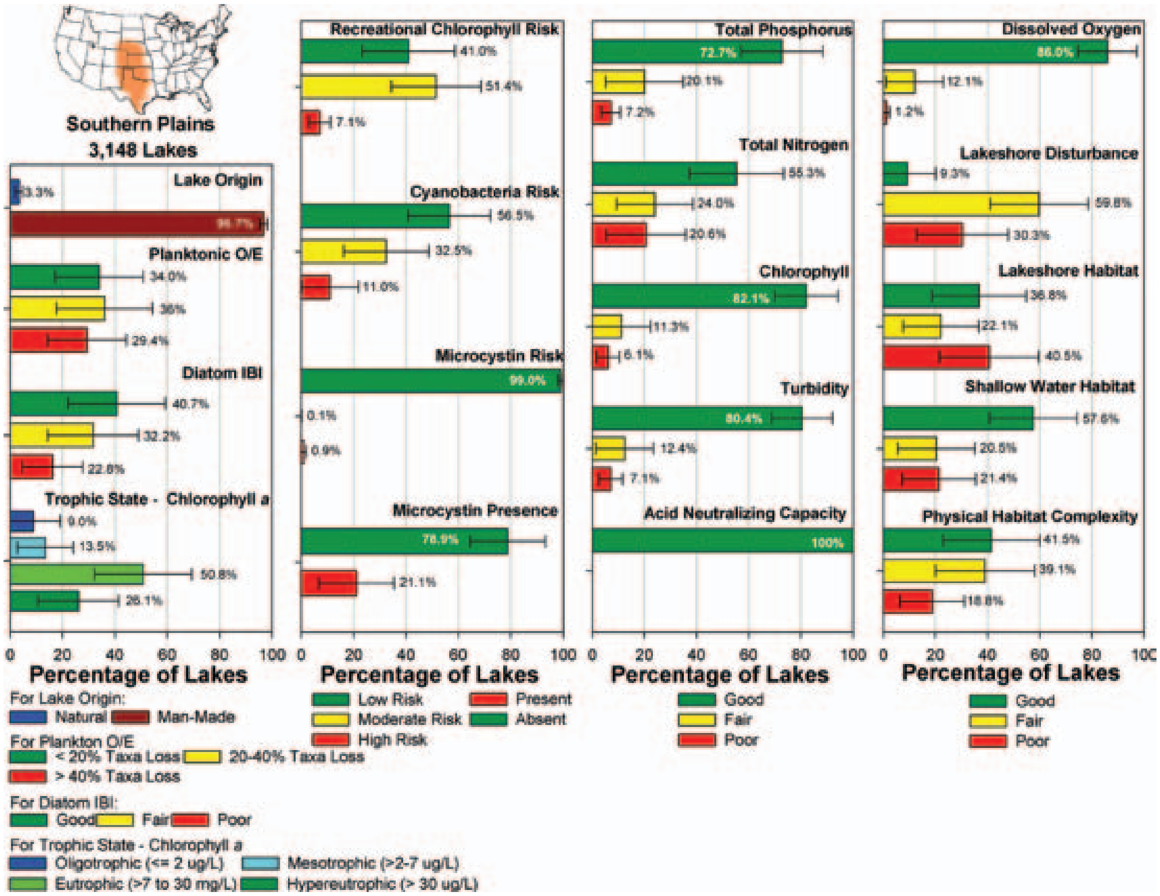


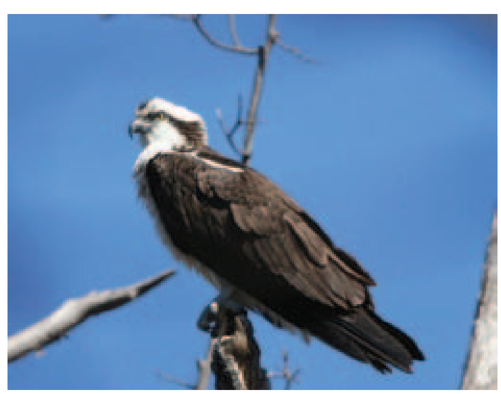
Figure 30. NLA findings for the Southern Plains. Bars show the percentage of lakes within a condition class for a given indicator. For Recreational Chlorophyll risk and Cyanobacteria risk, the percentage numbers indicate the risk of exposure to algal toxins associated with the presence of cholorphyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

Physical Habitat Stressors

Lakeshore habitat is fair to poor in 63% of the lakes in this ecoregion. The shorelines of Southern Plains lakes exhibit considerable disturbed conditions due to human activities. Ninety percent of lakes show moderate to high levels of lakeshore human disturbance.

Chemical Stressors

Water quality, based on the NLA chemical stressor indicators, is relatively good in the Southern Plains. Total phosphorus and nitrogen are considered good in 73% and 55% of lakes, respectively, and are poor in 7% and 20% of lakes, respectively. Relative to regionally-specific reference expectations, chlorophyll-*a* concentrations and turbidity levels are considered good in over 80% of lakes in this ecoregion. Lakes are generally in good condition based on ANC and surface water DO levels when compared to nationally-consistent thresholds. However, dissolved oxygen is fair in 12% of lakes.



Northern Plains

The Landscape

The Northern Plains ecoregion covers approximately 205,084 square miles (6.8% of the United States), including western North and South Dakota, Montana east of the Rocky Mountains, northeast Wyoming, and a small section of northern Nebraska. Federal lands account for 52,660 square miles or a relatively large 25.7% share of the total area. Terrain of the area is irregular plains interspersed with tablelands and low hills. This ecoregion is the heart of the Missouri River system and is almost exclusively within the Missouri River's regional watershed. Several major reservoirs are along the Missouri River mainstem, including Lake Oahe and Lake Sacajawea. The total surface area of lakes in this region is growing owing to increased runoff coupled with flat topography. Devil's Lake (ND) is one example, which in 1993 had a surface area of 44,000 acres and presently covers in excess of 130,000 acres.

Based on satellite images in the 1992 National Land Cover Dataset, the distribution of land cover is 56% grassland and 30% planted/cultivated, with the remaining 14% of land in other types of cover. A total of 2,660 lakes in the Northern Plains ecoregion are represented in the NLA, 77% of which are of natural origin.

Findings

A total of 65 of the selected NLA sites were sampled during the summer of 2007 to characterize the condition of lakes throughout this ecoregion. An overview of the NLA findings for the Northern Plains ecoregion is shown in Figure 31.

A Northern Plains lake.
Photo courtesy of Tetra Tech.

Biological Condition

The Northern Plains has the highest proportion of lakes in poor biological condition of any of the ecoregions. Ninety percent of lakes are in poor biological condition based on planktonic O/E, and 88% are in poor condition based on the diatom IBI.

Trophic Status

Based on chlorophyll-*a*, 8% of lakes are oligotrophic, 22% are mesotrophic, 48% are eutrophic, and 22% are considered hypereutrophic.

Recreational Suitability

Lakes in the Northern Plains exhibit the greatest risk of exposure to cyanobacteria and associated cyanotoxins of all ecoregions. Based on cyanobacterial counts, 59% of lakes exhibit moderate to high exposure risk. Microcystin was present in 75% of lakes.

Physical Habitat Stressors

Lakeshore habitat cover is considered good in only 7% of the lakes in this ecoregion. Regionally-specific habitat reference condition for the Northern Plains

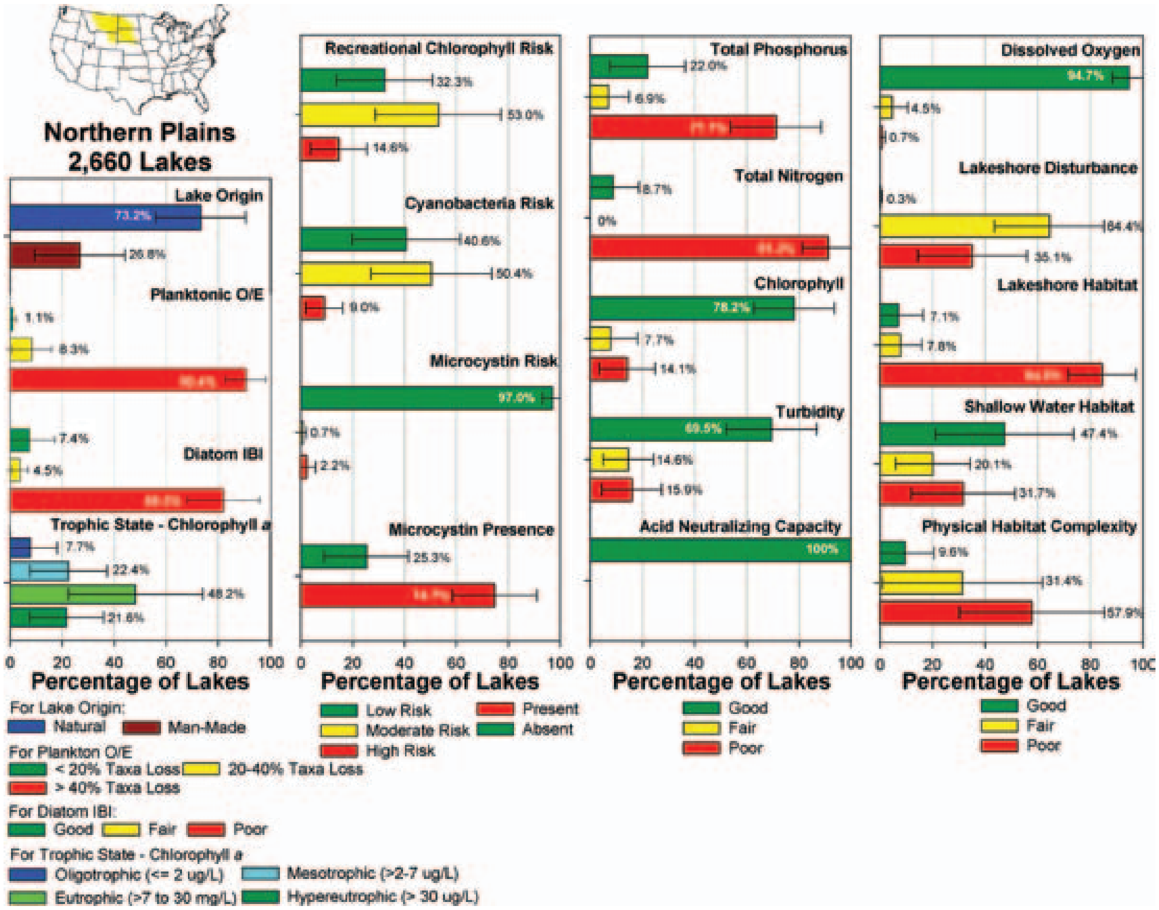


Figure 31. NLA findings for the Northern Plains. Bars show the percentage of lakes within a condition class for a given indicator. For Recreational Chlorophyll risk and Cyanobacteria risk, the percentage numbers indicate the risk of exposure to algal toxins associated with the presence of cholorphyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

is comprised of grasses and shrubs and is different from many of the other ecoregions where expectations include a tree layer in addition to a middle and lower story. Even taking into account the regional-specific expectations, the NLA data show that the Northern Plains lake shorelines exhibit very high levels of disturbance due to human activities. Ninety-nine percent of lakes show moderate or high levels of lakeshore human disturbance.

Chemical Stressors

Based on the NLA chemical stressor indicators, water quality is variable in the Northern Plains. In general, lakes in this ecoregion tend to have high levels of nutrients. Relative to regionally-specific reference expectations, total phosphorus concentrations are considered poor in 71% of lakes, while total nitrogen concentrations are considered poor in 91% of lakes. By contrast, based on chlorophyll-*a*, 78% of lakes are considered in good condition, and turbidity levels are good in 70% of lakes.

In the Northern Plains ecoregion, the traditional limnological concept that biomass production is controlled simply by nutrient concentrations may not apply. Lakes are generally in good condition based on ANC and surface water DO levels when compared to nationally-consistent thresholds.

Western Mountains
The Landscape

The Western Mountains ecoregion includes the Cascade, Sierra Nevada, Pacific Coast ranges in the coastal states; the Gila Mountains in the southwestern states; and the Bitterroot and Rocky Mountains in the northern and central mountain states. This region covers approximately 397,832 square miles, with about 297,900 square miles or 74.8% classified as federal land — the highest proportion of federal property among the nine aggregate ecoregions. The terrain of this area is characterized by extensive mountains and plateaus separated by wide valleys and lowlands. Lakes in this region, in particular those within smaller, high-elevation drainages, are very low in nutrients, are very dilute in other water chemistry constituents (*e.g.*, calcium). Therefore biological productivity in these systems is limited in their natural condition. Accordingly, these smaller, high elevation lakes are very sensitive to effects of human disturbances.

Lakes and ponds of the region range from large mainstem impoundments to high-mountain caldera and kettle lakes. Most famous among these mountain caldera lakes are Crater Lake (OR) and Lake Yellowstone (WY). The single deepest measurement of Secchi disk transparency recorded during the NLA – 122 feet (37 meters) – occurred in this ecoregion in Waldo Lake (OR). Based on satellite images in the 1992 National Land Cover Dataset, the distribution of land cover is 59% forest, 32% shrubland and grassland with the remaining 9% of land in other types of cover. A total of 4,122 lakes in the Western Mountains ecoregion are represented in the NLA, 67% of which are of natural origin.

Survey crews travel on horseback to reach remote lakes.
Photo courtesy of Tetra Tech.

Findings

A total of 155 of the selected NLA sites were sampled during the summer of 2007 to characterize the condition of lakes throughout this ecoregion. An overview of the NLA findings for the Western Mountains lakes is shown in Figure 32.

Biological Condition

Fifty-eight percent of lakes are in good biological condition based on planktonic O/E, and when using the diatom IBI, 50% of lakes in the ecoregion are in good biological condition relative to reference condition. Conversely, the percentages of lakes in poor condition are 11% and 3% based on the two analyses, respectively.

Trophic Status

Based on chlorophyll-*a*, 54% of lakes are oligotrophic, 26% are mesotrophic, 16% are eutrophic, and 4% are considered hypereutrophic. The Western Mountains ecoregion has the highest proportion of oligotrophic lakes (very clear with low productivity) of any of the ecoregions across the country.

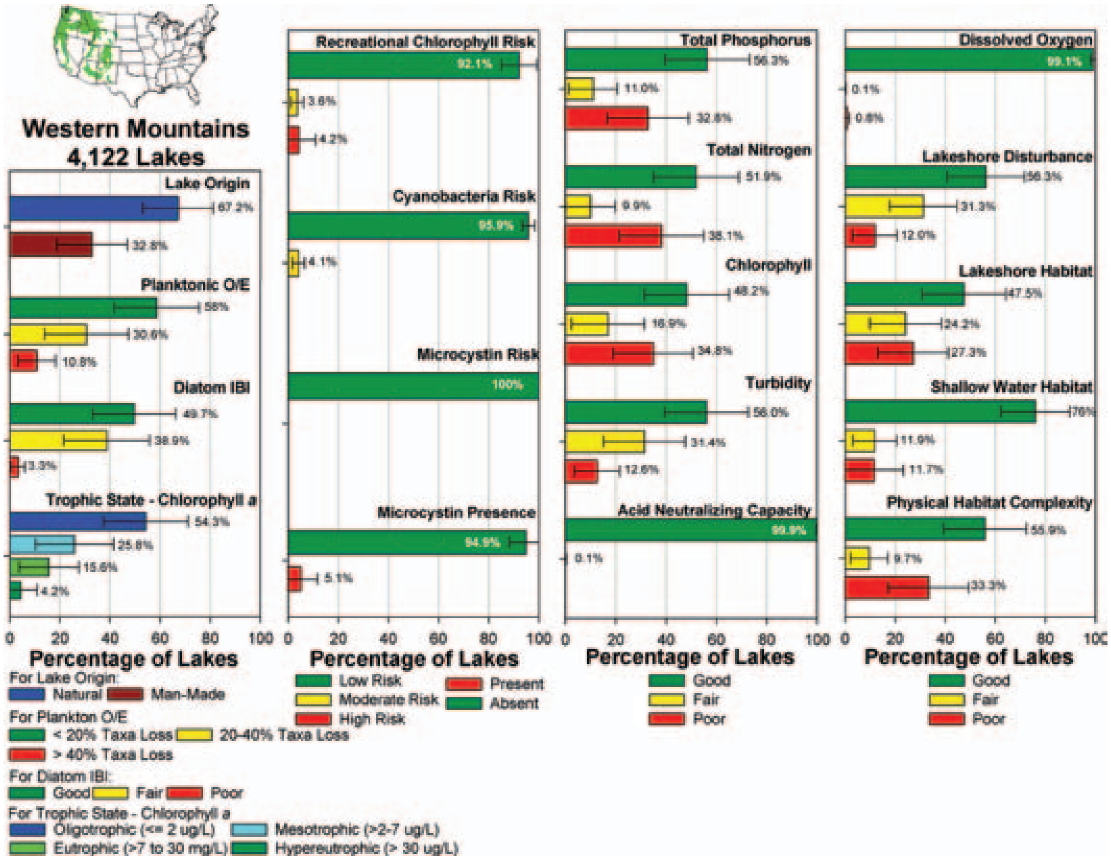


Figure 32. NLA findings for the Western Mountains. Bars show the percentage of lakes within a condition class for a given indicator. For Recreational Chlorophyll risk and Cyanobacteria risk, the percentage numbers indicate the risk of exposure to algal toxins associated with the presence of cholorphyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

Recreational Suitability

Lakes in the Western Mountains exhibit the lowest risk of exposure to cyanobacteria and associated cyanotoxins of all ecoregions. Based on cyanobacterial counts, 96% of lakes exhibit low exposure risk. Microcystin was present in only 5% of lakes.

Physical Habitat Stressors

Lakeshore habitat is considered good in 48% of the lakes in this ecoregion. Similar to the Northern Plains, regionally-specific reference conditions were modified in this ecoregion to account for sparse natural vegetation cover types expected in this mountainous region. With respect to human activity along the lakeshore, this ecoregion has the lowest percentage of lakes with human disturbance of all regions. Forty-three percent of lakes show moderate to high levels of lakeshore human disturbance.

Chemical Stressors

Based on the NLA chemical stressor indicators, water quality in the Western Mountains is consistently in the medium range. Relative to regionally-specific reference expectations, total phosphorus concentrations are considered good in 56% of lakes, fair in 11%, and poor in 33%. Total nitrogen concentrations are considered good in 52% of lakes, fair in 10%, and poor in 38%. Based on chlorophyll-*a,* 48% of lakes are considered in good condition, 17% in fair condition, and 35% in poor condition. Turbidity levels are good in 56% of lakes and fair in 31% of lakes. Lakes are in good condition based on ANC and surface water DO levels when compared to nationally-consistent thresholds.

Xeric
The Landscape

The Xeric ecoregion covers the largest area of all NLA aggregate ecoregions. This ecoregion covers portions of eleven western states and all of Nevada for a total of about 636,583 square miles (21.2% of the United States). Some 453,000 square miles or 71.2% of the land is classified as federal lands, including large tracts such as the Grand Canyon National Park (AZ), Big Bend National Park (TX), and the Hanford Nuclear Reservation (WA). The Xeric ecoregion is comprised of a mix of physiographic features. The region includes the flat to rolling topography of the Columbia/Snake River Plateau; the Great Basin; Death Valley; and the canyons, cliffs, buttes, and mesas of the Colorado Plateau. All of the non-mountainous area of California falls in the Xeric ecoregion.

In southern areas, dry conditions and water withdrawals produce internal drainages that end in saline lakes or desert basins without reaching the ocean. Large lakes in the southwestern canyon regions are the products of large dam construction projects. Water levels in these lakes fluctuate widely due to large-scale water removal for cities and agriculture. Recently, shifts in climate and rainfall patterns have resulted in considerably reduced water levels on several of the major Colorado River impoundments including Lake Mead, Lake Powell, and Lake Havasu. Based on satellite images in the 1992 National Land Cover Dataset, the distribution of land cover is 61% shrubland and 15% grassland, with the remaining 24% of land in other types of cover. A total of 802 lakes in the Xeric ecoregion are represented in the NLA, 91% of which are constructed reservoirs.

Lewis Lake, NM.
Photo courtesy of Tetra Tech.

Findings

A total of 84 of the selected NLA sites were sampled during the summer of 2007 to characterize the condition of lakes throughout the ecoregion. An overview of the NLA results for the Xeric ecoregion is shown in Figure 33.

Biological Condition

Thirty-seven percent of lakes are in good biological condition based on planktonic O/E, and when using the diatom IBI, 70% of lakes in the ecoregion are in good biological condition relative to reference condition. Conversely, the percentages of lakes in poor condition are 49% and 6% based on the two analyses, respectively. The difference between these two biological indices may suggest that the two indicators are responding to different stressors in lakes in this particular ecoregion.

Trophic Status

Based on chlorophyll-*a*, 22% of lakes are oligotrophic, 27% are mesotrophic, 22% are eutrophic, and 28% are considered hypereutrophic.

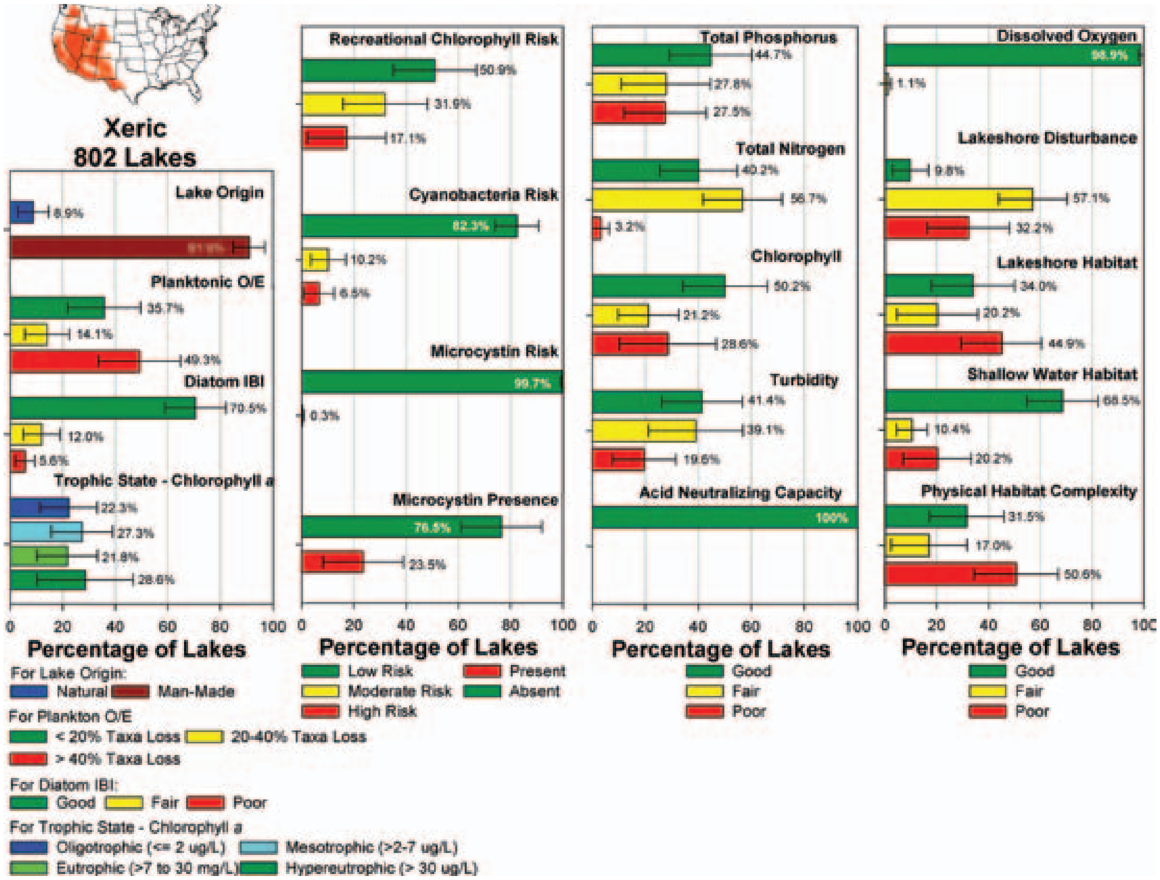


Figure 33. NLA findings for the Xeric. Bars show the percentage of lakes within a condition class for a given indicator. For Recreational Chlorophyll risk and Cyanobacteria risk, the percentage numbers indicate the risk of exposure to algal toxins associated with the presence of cholorphyll-*a* and cyanobacteria, not the risk of exposure to chlorophyll-*a* and cyanobacteria *per se*.

Recreational Suitability

Lakes in the Xeric ecoregion exhibit low to moderate risk of exposure to cyanobacteria and associated cyanotoxins. Based on cyanobacterial counts, 82% of lakes exhibit low exposure risk. Microcystin was present in 23% of lakes.

Physical Habitat Stressors

Lakeshore habitat is considered good in 34% of the lakes in this ecoregion. In the Xeric ecoregion, regionally-specific reference conditions were modified to account for sparse natural vegetation cover types expected in this dry region. Lakes in the Xeric ecoregion exhibit considerably disturbed conditions due to human activities. Over 89% of lakes show moderate to high levels of lakeshore human disturbance.

Chemical Stressors

Like the Western Mountains ecoregion to the north, the water quality in the Xeric ecoregion is in the medium range. Relative to regionally-specific reference expectations, total phosphorus concentrations are considered good in 45% of lakes, fair in 28%, and poor in 28%. Total nitrogen concentrations are considered good in 40% of lakes, fair in 57%, and poor in 3%. Based on chlorophyll-*a,* 50% of lakes are considered in good condition, 21% in fair condition, and 29% in poor condition. Turbidity levels are good in 41% of lakes, and fair in 39%. Lakes are good condition based on ANC and surface water DO levels when compared to nationally-consistent thresholds.

Partnerships for a Statewide Assessment of Lake Condition

Steve Heiskary
Minnesota Pollution Control Agency

In 2007, the Minnesota Pollution Control Agency (MPCA) along with the Minnesota Department of Natural Resources (MDNR) led the State's participation in USEPA's National Lakes Assessment survey. Various other collaborators were engaged in this study as well, including the U.S. Forest Service (USFS), the Minnesota Department of Agriculture (MDA), and U.S. Geological Survey (USGS). MPCA and MDNR combined on initial planning of the survey and conducted the vast majority of the sampling. USFS staff were instrumental in sampling remote lakes in the northeastern Boundary Waters Canoe Area Wilderness.

Minnesota was assigned 41 lakes as a part of the original draw of lakes for the national survey – the most of any of the lower 48 states. The State then chose to add nine additional lakes (randomly selected) to the survey to yield the 50 lakes needed for statistically-based statewide estimates of lake condition. In addition to the 50 lakes, three reference lakes were later selected and sampled by USEPA as a part of the overall NLA effort.

As part of its statewide assessment, Minnesota opted to add several measurements of unique interest to its overall state program. Examples of these add-ons are: pesticides; water mercury; sediment analysis of metals, trace organics and other indicators; macrophyte species richness; fish-based lake Index of Biotic Integrity (IBIs); and microcystin (at the index site and at a random near-shore site). A few of the findings are highlighted here. All of the reports completed to date can be found at: http://www.mpca.state.mn.us/water/nlap.html.

Pesticides

With the exception of the corn herbicide atrazine, pesticide degradates were more frequently detected than were the parent compounds. Possibly more of these parent compounds may have initially been present in a greater number of lakes, but had degraded prior to sampling. Alternately, parent compounds may have degraded early in the process, with degradates being subsequently transported to the lakes via overland runoff. Since the peak pesticide application period is late spring to early summer, mid-summer (July – August) lake sampling may have allowed ample time for degradation products to reach affected lakes. MDA was a key collaborator in this effort and conducted the pesticide analysis.

Detection of Pesticides and Pesticide Degradates in Minnesota Lakes

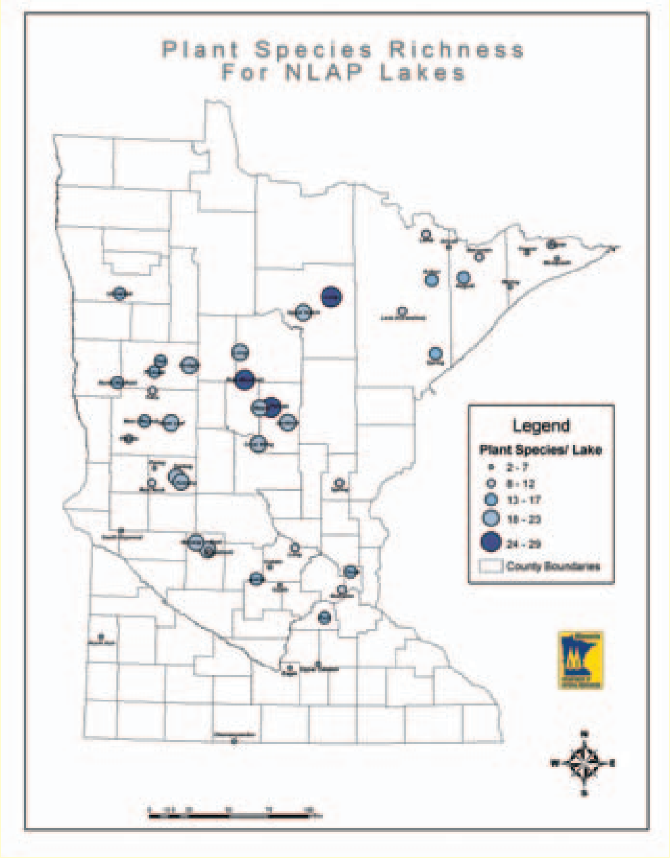
	Atrazine	Deisopropyl-atrazine	Desethy-atrazine	Metolachlor	Metolachlor ESA	Metolachlor OXA
Detection	present	non-detect	present	present	present	present
Detection freq.	87%	2%	64%	4%	27%	7%

Mercury levels

Measurement of total mercury (THg) and methyl mercury (MeHg) concentrations indicate that high levels of THg and MeHg are distributed throughout the state. The northeastern region has higher THg and MeHg concentrations compared to the southwestern region, although the MeHg fraction may actually be somewhat higher in the southwestern region. Otherwise, high THg and MeHg concentrations are distributed throughout the range of NLA lakes. These data can be used as a baseline against which to evaluate the efficacy of mercury emissions controls in MN. The USGS was an important partner in this effort

Aquatic Macrophytes

Plant species richness was assessed at ten random near-shore sites on each lake. Generally, species richness increases from south to north peaking in the north central portion of the State before decreasing in the northeastern arrowhead region. The general trend of increasing species richness from north to south can be explained by water clarity, water chemistry, and human disturbance, and reaffirms previous observations. The decrease in species richness in the northeastern portion of the state can be attributed to tannin stained waters and rocky substrate associated with Canadian Shield lakes located throughout this region.



Continuing Partnerships

Minnesota also is collaborating on a regional assessment of lakes in the Prairie Pothole Region with the states of North Dakota, South Dakota, Montana and Iowa and EPA Regions V and VIII. This collaboration will expand applications of statistically-derived data and serve to enhance state, regional and national lake assessment efforts.

CHAPTER 7.

CHANGES AND TRENDS

Photo courtesy of Great Lakes Environmental Center

IN THIS CHAPTER

- Subpopulation Analysis of Change – National Eutrophication Study
- Subpopulation Analysis – Trends in Acidic Lakes in the Northeast
- Sediment Core Analysis

Chapter 7
Changes and Trends

Among the long term goals of the National Aquatic Resource Surveys is the detection of changes and trends in both the condition of our Nation's aquatic resources and in the stressors impacting them. Trends in particular can be critical for policy makers *i.e.,* whether policy decisions have been effective or whether a different approach is needed to achieve important water quality goals.

This first survey of lakes and reservoirs provides clear information on current status and serves as the baseline for future changes and trends analyses. At this early stage the National Lakes Assessment is, however, able to incorporate three ancillary analyses to provide a cursory look at what changes have occurred. Over time, EPA intends to use further analysis and future surveys to start the trends analyses.

The first indication of change comes from the analysis of a subset of lakes surveyed in the 1970's and again in 2007. Between 1972 and 1976 the Agency and the states implemented the National Eutrophication Survey (NES) – a survey that included more than 800 lakes. The NLA was designed to allow for the comparison of some of the same lakes.

The second example of change is based on data in a regional study of acidic lakes in a subpopulation of lakes, *i.e.,* the northeastern U.S. Finally, a third examination of change involves the evaluation of cores from the lake sediments. By examining different cross sections within the sediment core and the microscopic diatoms present, analysts can infer past conditions in each lake.

Subpopulation Analysis - National Eutrophication Survey

Between 1972 and 1976, EPA conducted the National Eutrophication Survey. This study was designed to assess the trophic condition (defined as nutrient enrichment) of lakes influenced by domestic wastewater treatment plants (WWTP). The purpose of the survey was to measure nutrient inputs from all sources in the watershed relative to those of the WWTP source to determine if WWTP upgrades might be successful in modifying the lake or reservoir trophic state. While national in scope, it was unlike the NLA in that it was not probability-based. Instead it targeted a specific set of 800 wastewater impacted lakes.

For the NLA, a subset of 200 lakes from the 1972-1976 NES survey was randomly selected using the same probability design principles from the broader survey. This allowed the condition of all 800 lakes from the original NES survey to be inferred from

the subsample of 200 lakes sampled in 2007. The phosphorus levels, chlorophyll-*a* concentrations, and trophic condition of the NES population in 2007 could then be compared to what was observed in the 1970s to determine how these metrics have changed over the last thirty-plus years.

When making comparisons between then and now, some design differences between the two studies must be considered. NLA sampling consisted of a single, mid-summer integrated water sample at the deepest spot in the lake and from just below the surface to a depth of up to 2m (a sampling tube). The NES sampling consisted of sampling several sites on the lake as well as the inlets and outlets. NES sampling also included a site at the perceived deepest spot in the lake. Sampling was done with a depth-specific sampler (bottle) at just below the surface and at 1-2m depth intervals. Analysts compared the integrated sample NLA chlorophyll concentrations and NES samples taken at the site nearest the NLA site and from depth(s) that most nearly mimicked the depth of the NLA integrated depth sample. The accuracy and precision of chemical analytical results were considered comparable to each other based on the methods and the quality assurance of both surveys.

The NLA analysts looked at changes in the NES lakes over the past thirty-plus years using two approaches: by comparing concentration levels of key indicators and by examining trophic status. In both cases, researchers were able to estimate the number and percentage of NES lakes that showed a change since the original sampling in the 1970s. It is worth noting that this type of analysis provides an estimate of net change, but little information on change in individual lakes.

Phosphorus levels have decreased in more than 50% of the NES lakes (403) and for 24% (189) no change was detected. An increase in phosphorus levels was seen in 26% of the lakes (207) (Figure 34).

Trophic status based on chlorophyll-*a* also changed (Figure 35). Trophic status improved in 26% (184) of the lakes, and remained

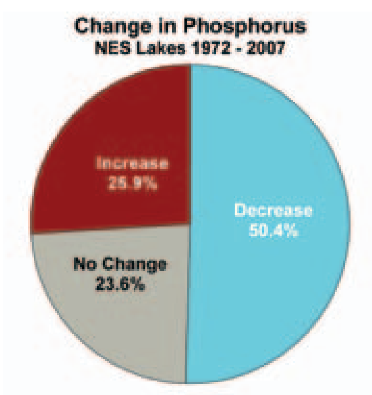


Figure 34. Proportion of NES lakes that exhibited improvement, degradation, or no change in phosphorus concentration based on the comparison of the 1972 National Eutrophication Survey and the 2007 National Lakes Assessment

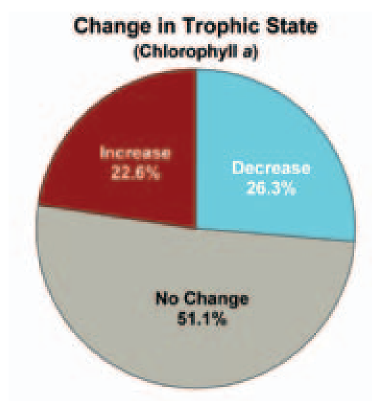


Figure 35. Proportion of NES lakes that exhibited improvement, degradation, or no change in trophic state based on the comparison of the 1972 National Eutrophication Survey and the 2007 National Lakes Assessment.

unchanged in over half (51% or 408 lakes) of the NES lakes. Trophic state degraded in 23% (208) of the NES lakes. Specifically, using chlorophyll-*a* as the indicator of trophic state, 49% of the lakes (394 lakes) in NES were classified as hypereutrophic in 1972. In 2007, that number had fallen to 35% (279) of the lakes. In 1972, just over 5% of the lakes were classified as oligotrophic and by 2007, over 14% of the lakes (117) were classified as oligotrophic (Figure 36).

Subpopulation Analysis - Trends in Acidic Lakes in the Northeast

A similar approach to assessing changes and trends was taken for lakes that are either acidic or sensitive to acidification as part of EPA's EMAP Temporally Integrated Monitoring of Ecosystems/Long Term Monitoring (TIME/LTM) program. During the 1980s, the National Surface Water Survey was conducted on lakes in acid sensitive regions across the country. Again, EPA was able to make some comparisons. The NLA results show that acidification of lakes affects a very small number of lakes nationally. However, in certain regions of the country, the problem is of concern, particularly when lakes smaller than 10 acres (4 hectares) are included.

Between the early 1990s and 2005, the acid neutralizing capacity in lakes in the Adirondack Mountains increased to a degree where many water bodies that were considered "chronically acidic" in the early 1990s were no longer classified as such in 2005 (Figure 37). Specifically, between 1991-1994 and 2005, the percent of chronically acidic waterbodies decreased in the Adirondack Mountains from 13.0% to 6.2%. Additionally, acid-sensitive lakes in New England were beginning to show a decrease in acidity. The percent of chronically acidic lakes in this region decreased from 5.6% in 1991-1994 to 4.3% in 2005. This trend suggests that lakes in these two regions are beginning to recover from acidification, though acidic surface waters are still found in these regions.

The trend of increasing ANC in lakes in the Adirondack Mountains and New England between the early 1990s and 2005 corresponds with a decrease in acid deposition in each of these regions and reduced air emissions of the main components to acid deposition, which are sulfur dioxide and nitrogen oxides.

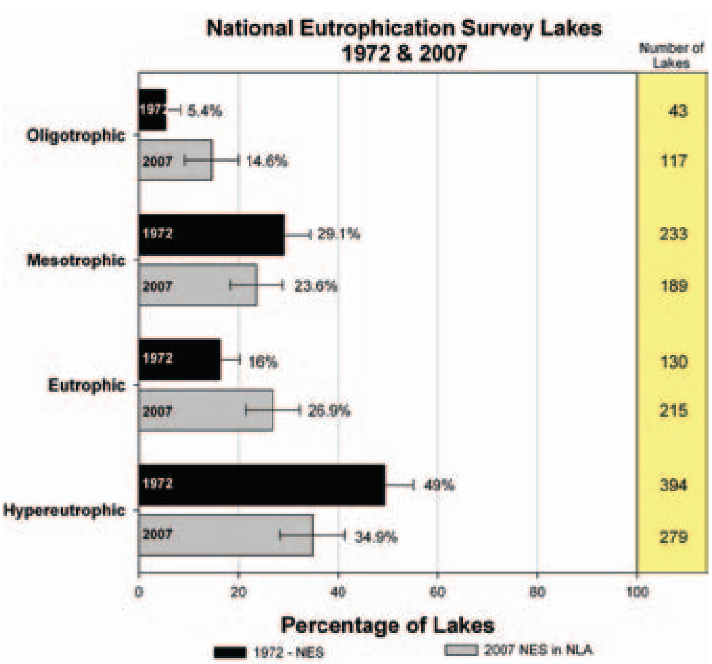
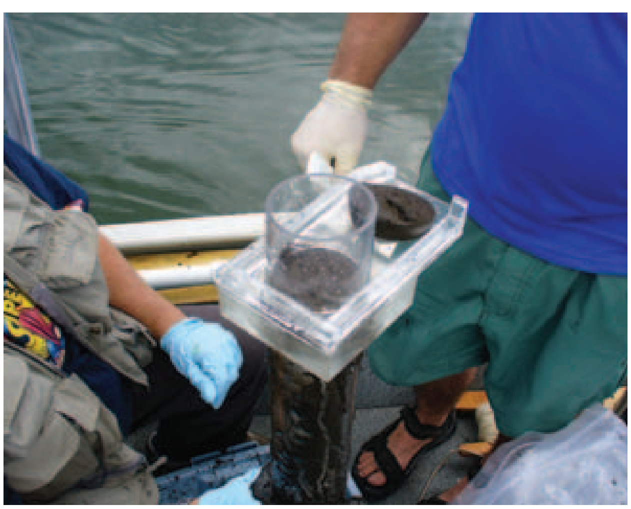


Figure 36. Percentage and number of NES lakes estimated in each of four trophic classes in 1972 and in 2007 based on chlorophyll-*a* concentrations.

Sediment Core Analysis

In the third examination of change, the NLA incorporated paleolimnological analyses, a technique that uses lake sediment cores to obtain insights about past conditions. NLA analysts looked at thin slices of sediment cores and identified diatom silica casings. The community of diatoms present in each slice gives clues to the chemical and physical conditions in the lake when that layer was deposited. Models have been developed to relate the diatom community to lake chemistry characteristics, such as total phosphorus, and to lake physical characteristics, such as clarity. Using these relationships, the diatoms in deeper layers of the sediment were identified and the chemical conditions present at that point in time were inferred. This technique was used very effectively during studies of acidification in lakes during the 1980s. Individual states and other organizations have also used sediment cores in this manner on more localized/ regional scales to improve our understanding of what lakes were like in the past.

EPA piloted this technique for application at a national scale to examine temporal change in a subset of lakes included in the NLA. In the field, the top layer of the sediment core was collected along with a layer deep in the core. Unfortunately, EPA was unable to date the sections of the core to confirm their age. Instead, NLA analysts used independent techniques, their own expertise, and the knowledge of regional experts to determine whether the cores were sufficiently deep for NLA purposes. The Agency acknowledges that this approach is a less reliable means of estimating the age of the cores.



Slicing off the top layer of the sediment core for diatom analysis. Photo courtesy of Frank Borsuk.

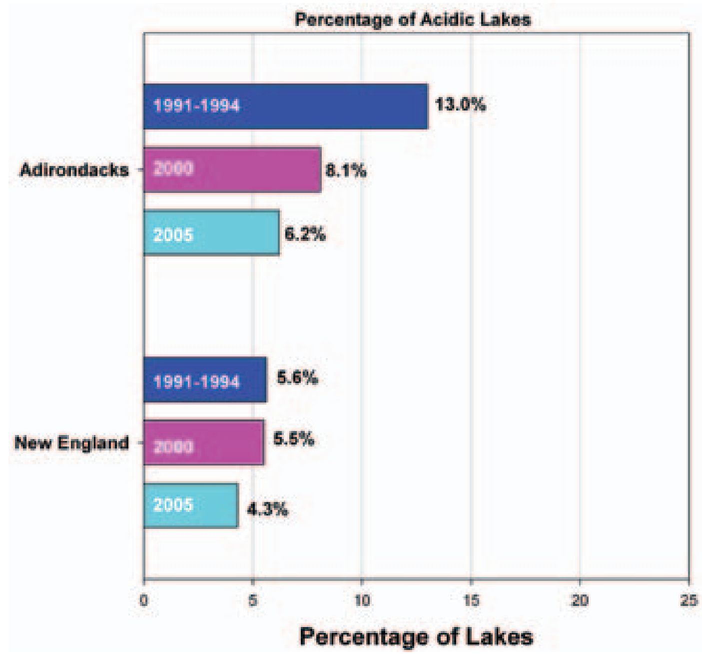


Figure 37. Change in percentage of chronically acidic lakes in the Adirondack Mountains and New England.

For man-made lakes the bottom layer of the sediment cores was not collected because it was presumed sediment cores in these more recent lakes would not represent a pre-industrial condition. Three hundred ninety-two lakes, representing 34% of the target population, were in this category and also were not evaluated. In addition, 334 lakes, representing about 22% of the target population, were not evaluated because the core length was insufficient. In the end, change estimates were possible for 426 lakes, representing 55% of the target population.

Even though the percentage of target population is less than optimum, some information can be gleaned from the data. Results from the cores showed that an estimated 17% of lakes in the lower 48 states exhibited no significant change in inferred total phosphorus between the bottom of the core and the top of the core. A decrease in total phosphorus was estimated to have occurred in 12% of the lakes while almost 7% of lakes were estimated to have experienced an increase in total phosphorus. The pattern in changes for total nitrogen differs somewhat. Nationally, the percentage of lakes showing no change between the top and bottom of the core is less than 5%. Sixteen percent of the lakes showed an increase in total nitrogen while 18% showed a decrease in total nitrogen.

The difference between the top and bottom of the sediment cores suggests that many lakes may have lower total phosphorus and total nitrogen levels now than they once did. Without dating the cores, however, more information and analysis are needed in explaining these results.

While results from this approach are presented below, further analyses will be necessary to determine if sediment core dating should be included in future lake surveys. Issues for consideration include evaluating:

- Whether the approach used is sufficiently robust to identify cores reaching pre-industrial times across the country;
- Whether the assessment of change in a relatively small subset of lakes merits the effort expended in the context of a national survey; and
- Whether alternative coring and/or dating approaches should be considered for future iterations of the NLA.

Photos courtesy of USEPA Region I

Measuring lake depth.

HIGHLIGHT
Climate Impacts on Lakes

Warmer Temperatures and Lake Condition

The preponderance of information indicates that the planet is warming and significant changes in climate are expected around the globe. The International Panel on Climate Change (IPCC) unequivocally attributes the climate change to human activities that have increased greenhouse gases in the atmosphere. The United States alone saw an increase of 1° (F) over the last century. Most of the warming has occurred in the last three decades and the largest observed warming across the country has taken place in the winter months. In southern areas, surface water temperatures are surpassing those of air temperatures, while in the north, there is ample evidence of earlier ice-out dates. For lakes, these changes will impact reservoirs and drinking water sources, hydroelectric power facilities, irrigation regimes, shipping and navigation, and recreational opportunities. From an ecosystem standpoint, warmer lakes will result in changes in water depth, thermal regime, nutrient loading, retention time, mixing and oxygen availability, and suspended sediments – all of which will alter habitat suitability and lake productivity.

Photo courtesy of Great Lakes Environmental Center

Changes in the Upper Midwest — The Great Lakes

While scientists generally agree that the nation will get slightly wetter over the next century, precipitation trends at a regional level are uncertain. In many areas, however, increased rainfall could be offset by increased evaporation, both in terms of soil moisture and surface water. The Great Lakes, which hold 18% of the world's fresh surface water, are being watched carefully. Many agree that warming trends throughout the region will lead to a climate more comparable to the Deep South thus making the lakes themselves smaller and muddier. Since 1988, temperature in Lake Erie has risen 1° (F) and while predictions vary, some researchers forecast that by 2070, lake level will fall about 34 inches and surface area will shrink 15%. This scenario would leave 2,200 square miles of new land exposed. Lower water levels and less ice cover will lead to more sediment delivery, and therefore more algae and potentially more waterborne diseases. Excessive algal blooms can affect aquatic life and harm animals and humans. Climate changes will also affect fish populations and zooplankton communities due to the disruptions in lake dynamics such as the timing and severity of ice-cover, winter-kill and spring/fall turn-over.

Changes in the Southwest – Lake Tahoe and Lake Mead

Persistent drought conditions, increased extreme rainfall events, more wildfires, and heightened flooding, runoff and soil erosion are all expected to afflict the already arid southwest. Since 1988, the average surface water temperature of Lake Tahoe has increased by 1° (F). Other signs of persistent warming are decreased snowfall, later snowfall, and earlier snowmelt. In Tahoe City, California, the percentage of precipitation falling as snow has dropped from 52% in 1910 to 35% in 2007 and since 1961, peak snowmelt throughout the lake region has shifted earlier by two and a half weeks. In *Tahoe: State of the Lake Report 2008*, researchers reported that algal growth, considered an indicator of warming's acceleration, has increased rapidly with concentrations now five times what they were in 1959. Levels of nitrogen and phosphorus deposited from the Angora forest fire (also considered a climate indicator) also were 2-7 times greater than normal.

Photo courtesy of Great Lakes Environmental Center

Fluctuations in precipitation and snowpack have critical impacts on life in the desert. In Nevada, the water level in Lake Mead is steadily dropping and with it the hydroelectric production capacity by Hoover Dam. Studies cited by the National Conference of State Legislatures and Center for Integrative Environmental Research (2008) indicate that there is a 10% chance that Lake Mead could dry up by 2021 and a 50% chance it will be dry by 2050. Lake Mead provides drinking water for over 2 million people and generates electricity for over 1.3 million. Water-based recreation brings in more than $1 billion to the area's economy. Major changes in annual precipitation and snowpack are proving difficult for reservoir managers who must balance winter flooding with maximum capture and storage for summer water needs — all within the context of overall declining water levels.

What the Experts Say

How a changing climate will impact the country's lakes is far from understood and not easy to grasp. The Climate Change Science Program, in its 2008 report, underscores that most observed changes in water quality across the continental U.S. are likely attributable to causes other than climate change and are instead primarily due to changes in pollutant loadings. Nevertheless, there is general agreement with the IPCC (2007) conclusion that higher water temperatures, increased precipitation intensity and longer periods of low levels are likely to exacerbate many forms of water pollution, with impacts on ecosystem integrity, and water system reliability and operating costs. Both groups agree that a mix of mitigation and adaptation will be necessary to address the impacts.

CHAPTER 8. CONCLUSIONS AND IMPLICATIONS FOR LAKE MANAGERS

Photo courtesy of Great Lakes Environmental Center

IN THIS CHAPTER

- ► Overall Findings and Conclusions
- ► Implications for Lake Managers

Photo courtesy of Jim Anderson and Dennis McCauley

Chapter 8
Conclusions and Implications for Lake Managers

Overall Findings and Conclusions

The NLA offers a unique opportunity to frame discussions and planning strategies based on environmental outcomes and across jurisdictional lines. It serves as a first step in the evaluation of the collective successes of management efforts to protect, preserve, or restore water quality. Attributable risk analyses can serve as a useful tool to help prioritize individual stressors. As EPA and its partners repeat the survey, the NLA will be able to track changes in water quality over time for lakes as a whole rather than just for a few individuals. This will help advance the understanding of important regional and national patterns in water quality, and speak to the cumulative effectiveness of the national water program.

Taken together, the results of the NLA provide a broad range of information necessary to understand the condition of our nation's lakes and some of the key stressors likely to be affecting them. The results are especially important because they establish a national baseline for future monitoring efforts which can be used to track statistically-valid trends in lake condition. These stressors in lake systems are now placed in context of their relative importance for restoring and maintaining lake integrity.

Condition of the Nation's Lakes

The results of the survey provide information relating to the fundamental question of "what is the condition of the nation's lakes?" The NLA reports on condition in three important ways. Biological indicators are especially useful in evaluating national condition because they integrate stress of combined problems over time. The NLA shows that 56% of the nation's lakes are in good condition, 21% are in fair condition, and 24% are in poor condition based on a measure of planktonic O/E taxa loss. Recreational suitability is based on the algal toxin, microcystin. Microcystin was found to be present in approximately one-third of lakes and at levels of concern in 1% of lakes. Finally, trophic status results based on chlorophyll-*a* concentrations show that 20% of lakes are hypereutrophic, while 80% are in lower nutrient enrichment categories.

Ecoregional assessments reveal broad-scale patterns in lake condition across state lines and across the country. Again using biological condition as the primary indicator of lake health, the Northern Appalachians, the Upper Midwest and the Western Mountains ecoregions have the greatest proportion of lakes in good condition – over half of the lakes in each of these regions are classified as good.

While it is too early in the survey program to determine if overall lake condition is improving, NLA analysts were able to examine changes in one subset of lakes, first sampled more than thirty years ago. It is encouraging to see that trophic status improved in 26% of the NES lakes and remained unchanged in 51% of the lakes. This means that trophic status in over three-quarters of these lakes remained the same or even improved despite growth of the U.S. population.

Major Physical and Chemical Stressors to Biological Quality

The NLA results show that of the physical indicators measured in the study, degraded lakeshore habitat is the most significant stressor to poor biological integrity. Using this as the primary habitat indicator, just under half of the country's lakes (45%) are in good condition. The NLA results also show that lakes in poor condition for habitat are 3 times more likely to be in poor biological condition. Another physical habitat indicator examined was the presence of human activities. From the standpoint of human disturbances along lakeshores, just one-third (35%) of the country's lakes are in good condition. Conversely, in addition to exhibiting good biological conditions, about half of the lakes in the relatively healthy Northern Appalachians, the Upper Midwest and the Western Mountains ecoregions, are in good habitat condition relative to other ecoregions across the country.

About 40% of the nation's lakes are constructed reservoirs.
Photo courtesy of Eric Vance.

Nutrients in the form of phosphorus and nitrogen are the second most important stressor to lake biological health. Fifty-eight percent of lakes are in good condition relative to total phosphorus levels and 54% are in good condition relative to total nitrogen. Lakes in poor condition for either of these stressors are twice as likely to be in poor biological condition. Yet, unlike habitat condition, nutrient levels vary widely across the country. The Northern Appalachians ecoregion has the greatest percentage of lakes in good condition relative to total phosphorus (TP) and total nitrogen (TN) (79% for TP and 88% for TN) while the Temperate Plains (38% for TP and 27% for TN) and the Northern Plains (22% for TP and 9% for TN) ecoregions have the lowest.

Implications for Lake Managers

While survey results fill key informational gaps in regional and national monitoring programs by generating estimates of the condition of water resources, evaluating the prevalence of key stressors, and documenting trends in the population of waters over time, they do not address all management concerns at all scales. For example, the lakes survey does not address causal factors or sources of stress. For water resource managers and city planners, efforts to reduce stresses and improve water quality entails confronting the source(s) of the stress (such as energy generation, agricultural production, or suburban development) and working toward implementing viable but often difficult solutions.

Address Major Lake Stressors

State lake management programs increasingly report that development pressures on lakes are steadily growing. The NLA findings show that local, state, and national initiatives should center on shoreline habitats, particularly vegetative cover, and nutrient loads to protect the integrity of lakes.

The findings of the four physical habitat indicators show that poor habitat condition imparts a significant stress on lakes and could suggest the need for stronger management of lakeshore development at all jurisdictional levels. Of the four, degradation of lakeshore habitat cover is the most important stressor of lakes. The attributable risk analysis suggests that eliminating this stressor could restore the biological condition in 40% of lakes that are classified as poor, or 8.8% of lakes nationwide. Development and disturbance stressors along lakeshores (such as tree removal, residential construction, and grazing and cropping practices) impact the integrity of lakeshore and shallow water habitats, affecting terrestrial and aquatic biota alike.

These NLA results support the continuing need for national, state, and local efforts to ameliorate the impacts of human activities in and around lakes to protect the lake ecosystem. For example, USDA's Conservation Reserve Enhancement Program supports the planting of buffers to serve as natural boundaries between water bodies and farm land. EPA's Low Impact Development (LID) program helps address lakeshore development pressures (see text box on page 86).

Nutrients have been a longstanding stressor of waterbodies in this country. Nationally, over 40% of the lakes exhibit moderate or high levels of nitrogen or phosphorus concentrations. In addition, regional hotspots are evident - in the Temperate and Northern Plains, nearly all lakes have high levels of nutrients. The NLA findings emphasize the need for continuing implementation of Federal-State partnership programs to control point and non-point sources of nutrient pollution. The NLA data can be used to support and enhance collaboration between jurisdictional authorities and the use of programs such as the Environmental Quality Incentives Program and Conservation Reserve and Enhancement Programs managed by USDA's Natural Resources Conservation Service, and the Section 319 Program and National Pollutant Discharge Elimination System run by EPA.

Track Status and Trends Information

Lake managers should consider the national trend information as well as the ecoregional data in evaluating site specific information in a broader context. Conducted on a five-year basis, subsequent lake surveys will help water resource managers to assess temporal differences in the data and perform trends analyses. Future surveys will also help EPA and its partners evaluate national and ecoregional stressors to these ecosystems, track changes, and explore the relative importance of each in restoring or maintaining waterbody health. Wide-area or regional changes in stressors over time can potentially be linked to human factors such as land use changes (*e.g.*, development) or natural causes (*e.g.*, increased storm surges).

Implement Statewide Statistical Surveys

Statistical survey designs provide water resource managers and the public with consistent, statistically-valid assessments of the broader population of waters in the area of interest (nationally, state-wide, *etc.*) based on data from a relatively small representative sample. Information provided by these surveys can help managers monitor the effectiveness of their lake restoration and pollution control activities as well as target resources and additional monitoring where they are most needed. To date, 40 states are implementing statistical surveys (Figure 38). These states are leveraging their limited monitoring resources to gain state-wide insights into their water resource quality. EPA encourages states to implement state-wide statistical surveys as a component of their CWA monitoring program.

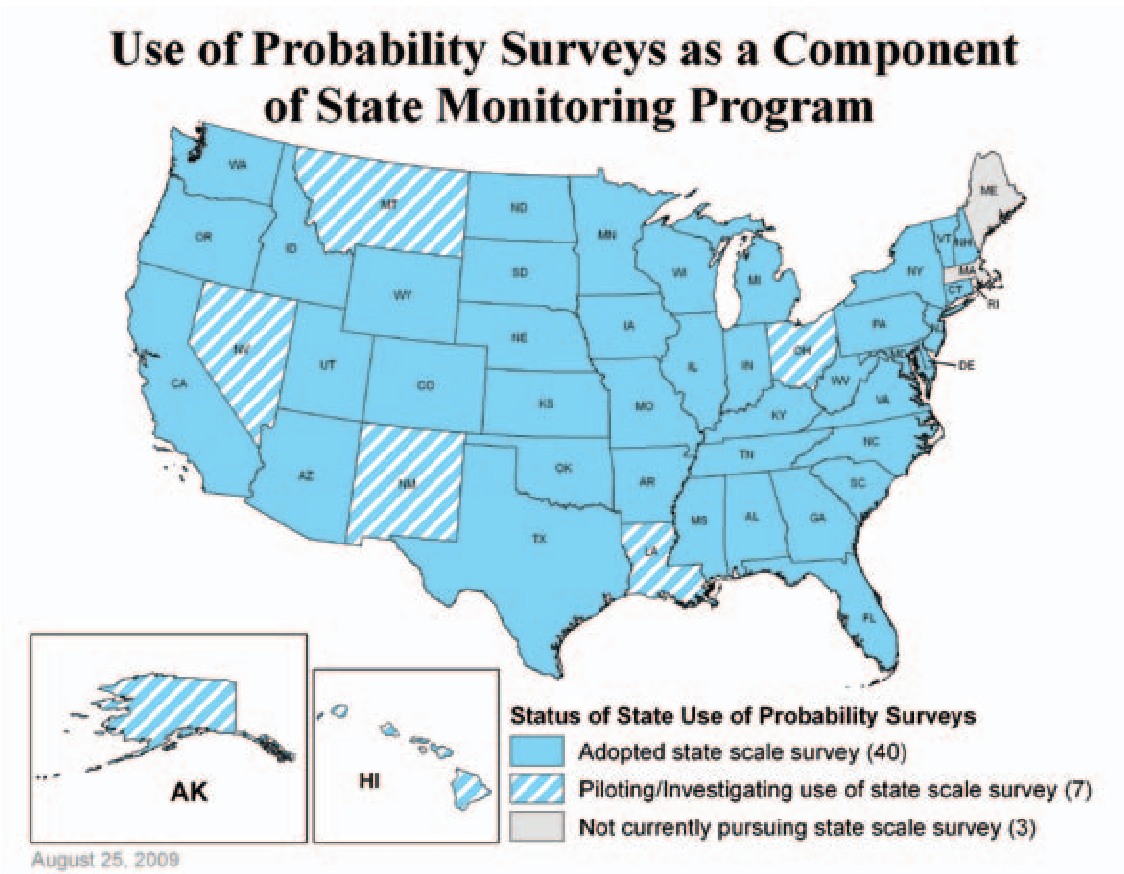


Figure 38. States with state-scale statistical surveys.

Low Impact Development Protects Lake Quality

Low impact development (LID) is a set of approaches and practices that are designed to reduce runoff of water and pollutants from the site at which they are generated. LID techniques manage water and water pollutants at the source through infiltration, evapotranspiration, and reuse of rainwater, preventing many pollutants from ever reaching nearby surface waters. LID practices include rain gardens, porous pavements, green roofs, infiltration planters, trees and tree boxes, and rainwater harvesting for non-potable uses such as toilet flushing and landscape irrigation. The primary goal of LID is to design each development site to protect, or restore, the natural hydrology of the site so that the overall integrity of the watershed is protected.

Development typically causes an imbalance in the natural hydrology of a watershed by replacing pervious surfaces (*e.g.*, fields, forests, wetlands *etc.*) with impervious surfaces (*e.g.,* rooftops, parking lots, roads, *etc.*). This change in ground cover not only increases runoff because of decreased infiltration, it also reduces the potential for the removal of nonpoint source pollutants.

By engineering terrain, vegetation, and soil features, LID practices promote infiltration of runoff close to its source and help prevent sediment, nutrients, and toxic loads from being transported to nearby surface waters. Once runoff is infiltrated into soils, plants and microbes can naturally filter and break down many pollutants and restrict movement of others.

Implementing LID practices in watersheds will contribute to groundwater recharge, improve water quality, reduce flooding, preserve habitat, and protect lake quality. In addition, LID practices increase land value, aesthetics and recreational opportunities, and public/private collaborative partnerships while reducing stormwater management costs. For more information visit: http://www.epa.gov/owow/nps/lid.

States with statistical survey programs are already using the results to develop watershed-scale or site-specific protection or restoration projects. Virginia, for instance, has established an intensive water quality monitoring program incorporating statistical sampling methods. South Carolina's monitoring program includes a statistically-based component to complement its targeted monitoring activities. Each year a new statewide set of statistical random sites is selected for each waterbody type, *i.e.*, streams, lakes/reservoirs, and estuaries.

The State of Florida also implements an annual probabilistic monitoring program. Their program will be an enhancement of its 2000 Status Monitoring Network — a five-year rotating-basin, statistical design sampling of six water resources, including small lakes (1-10 hectares) and large lakes (>10 hectares). Florida is currently in the fifth year of the Network and will report its findings in 2010.

State-wide surveys can be leveraged with the national survey and the information can be used in conjunction with other existing state monitoring programs to get a better understanding of the state's waters. In the same way that a lake association might relate the conditions it measures in a particular lake to other lakes, state/tribal managers can relate the conditions of lakes statewide to relevant ecoregional or national conditions. For example, Vermont compared its lakes' trophic status to the lakes in the Northern Appalachians ecoregion and nationwide

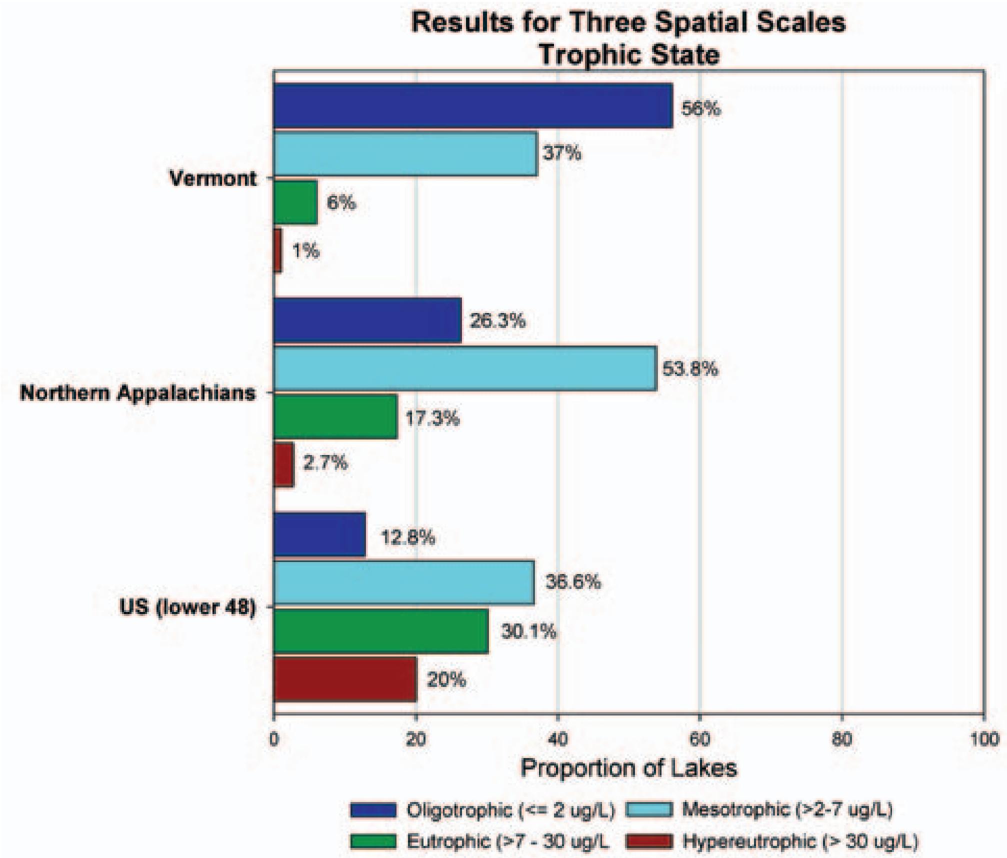


Figure 39. Comparison of lakes by trophic state for Vermont, the Northern Appalachians ecoregion, and the Nation, based on chlorophyll-*a*.

(Figure 39). This assessment shows that lakes in Vermont are more oligotrophic than lakes at the NLA ecoregional or national scale. Lake managers in states with a statistical survey network can use information such as this to target resources and management efforts.

Incorporate New and Innovative Approaches

EPA is encouraging states, tribes, and others to utilize NLA data and methods for their own customized purposes. The NLA provides lake managers with new tools and techniques to adopt into existing programs. Managers are encouraged to consider the host of new assessment indicators and methods that are applicable within assessment programs of any scale. For example, the quantitative assessment of physical habitat at the land-water interface is an area of intensifying focus within the lakes community. The NLA physical habitat assessment method provides a ready approach that has already been implemented by field crews across the lower 48 states and Alaska. The resulting data are readily reduced to four components of habitat integrity that relate directly to ecological integrity in lakes. For lake assessment programs lacking a physical habitat assessment component, the NLA method provides a low-cost and information-rich enhancement.

The incorporation of recreational indicators within lake assessment programs can also yield useful information to lake managers. Public awareness of cyanobacteria and related toxins is increasing, fueled in part by an increasing number of beach closures and related media reports. In the NLA, while only a small proportion of lakes exhibited moderate or high-risk concentrations of microcystin, the proportions of lakes with concentrations of chlorophyll-*a* or cyanobacteria cells associated with the development of elevated microcystin was considerably greater. Routine monitoring of chlorophyll-*a*, cyanobacterial cell counts, and/or microcystin can be implemented using a tiered approach tailored to the likelihood of microcystin occurrence. Many states are now adopting such programs, resulting in greater protection of human health in instances where cyanobacteria blooms may limit or prohibit swimming.

Work Beyond Jurisdictional Boundaries

Survey data on a national scale allows for aggregation of data and comparability of the results across several ecoregional levels. Within each of these ecoregions, states often share common problems and stressors to shared watersheds. The NLA offers a unique opportunity for adjacent states to work together, establish coalitions, and put into place collaborative actions that cross state boundaries. As a starting point, EPA and its state partners are working together to develop approaches to monitoring that will allow comparisons on a state-wide basis and across state boundaries as well. EPA and the states are committed to finding mutually-beneficial and scientifically-sound ways to integrate and exchange data from multiple sources, as well as options to improve both sample collection and analytical methods.

Aquatic weed harvesting is one way to manage plant growth.
Photo courtesy of Frank Borsuk.

Pennsylvania spillway.
Photo courtesy of Frank Borsuk.

HIGHLIGHT

State, Tribal, and Regional Lake Surveys: Examples From Across the Country

State-wide Lake Assessments

Oklahoma: Oklahoma was one of several states that chose to add to the number of nationally-selected lake sites within its boundaries to achieve a state-wide assessment. Oklahoma is looking into using National Lakes Assessment (NLA) survey data for further development of nutrient and biological criteria, incorporating new parameters into its established monitoring program, and nesting a probability-based survey into its fixed station rotation.

Michigan: Twenty-nine Michigan lakes were randomly selected as part of the NLA. To allow for a state-scale assessment, the state added 21 additional randomly-chosen lakes. Michigan's surveyed lakes ranged from an unnamed 10-acre lake in Clare County to 13,000-acre Gogebic Lake in Gogebic County. The state will continue to analyze its lake data set to further evaluate the condition of Michigan's inland lakes based on the national survey assessment tools.

Ice Lake in the Eagle Cap Wilderness.
Photo courtesy of Oregon Department of Environmental Quality.

Oregon: Oregon sampled 30 lakes across the state as part of the NLA. In Oregon, the results from the 2007 NLA will help answer two key questions about the quality of lakes, ponds and reservoirs: What percent of Oregon's lakes are in good, fair or poor condition for key indicators of nutrient status, ecological health and recreation? What is the relative importance of key lake "stress factors" such as nutrients and pathogens? The random design took field crews to a wide variety of sites. Elevation at the target lakes ranged from 30 feet to 7,850 feet. Lake depths ranged from 1 meter to 128 meters (Waldo Lake); maximum sampling depth, however, was 50 meters. The most difficult lake to reach was Ice Lake in the Eagle Cap Wilderness, which required the use of an outfitter and horses for the eight-mile and 3,300-foot elevation gain journey.

Enhancing Lake Monitoring for the Lac du Flambeau Tribe, Wisconsin

The Lac du Flambeau Tribe is using the NLA study to enhance its own water program. The ability to develop protective site-specific water quality criteria and assess lake health is limited when available data cover only a small geographic area such as the Lac du Flambeau Reservation. Participation in the NLA enabled the Tribe to compare Reservation lake data to national and regional lake health. The Tribe used the NLA protocols for physical habitat, water chemistry, and vertical water profiles on an additional 11 lakes within the Reservation. These data are being entered into EPA's Water Quality Exchange (WQX) using an Excel template to ensure data uniformity for comparison. The Tribe will develop lake report cards for the general public, managers, and decision makers assessing the health of Reservation lakes as compared to national and regional lake health. The Tribe will also be able to evaluate development of criteria using these data.

Assessing Prairie Potholes: A Collaborative Effort.

The Prairie Pothole Region crosses the north central U.S. and Canada and includes nearly 8,000 prairie pothole lakes. Prairie pothole lakes are intrinsically shallow and defined as natural lakes where 80% or more of the lake is less than 15 feet deep. Prairie Pothole lakes are part of a major waterfowl fly-way and are a valuable regional and national resource. In order to more fully understand this unique ecosystem, North Dakota, Iowa, Minnesota, South Dakota, Montana, USGS, and EPA undertook an assessment of these lakes. Analysts have found that nutrient and chlorophyll-*a* levels in Prairie Pothole lakes are quite high compared to the nation's lakes. A combination of high nutrient levels, elevated algae growth, low transparency, presence of roughfish, and broad, wind-swept basins serve to limit rooted plant growth. Maintaining rooted plant growth is important for Prairie Pothole health. More detailed information on the results of the Prairie Pothole survey will be provided in a NLA supplemental report.

Photo courtesy of Wes Weissenburger

CHAPTER 9.

NEXT STEPS FOR THE NATIONAL SURVEYS

Bayley Lake in Stevens County was one of the lakes the Department of Ecology sampled during the survey.
Photo courtesy of Washington State Department of Ecology.

IN THIS CHAPTER

- Supplemental Reports
- Tools and Other Analytical Support
- Future National Assessments

Photo courtesy of Lauren Wilkinson, Great Lakes Environmental Center.

Chapter 9
Next Steps for the National Surveys

EPA is committed to continually enhance the National Aquatic Resource surveys in order to improve the quality and quantity of information it needs to understand the condition of the aquatic environment and how it is changing over time. As technologies advance, future surveys and collaborations can also lead to new indicators, new monitoring approaches, and new water resource management programs and policies.

With the publication of this report, the lakes survey moves into a design/planning phase in preparation for the next survey in 2012. This phase will incorporate lessons learned from the first lakes survey, other national surveys, and state, tribal and local experiences. Additionally, EPA anticipates that states and other partners will continue to utilize data from the first lakes survey and issue supplemental reports based on their findings.

During 2010, EPA and its state and tribal partners will take stock of the survey and begin planning for 2012. Issues for discussion may include changes to the design, field methods, equipment, laboratory methods, and/or analyses procedures. Other items include improving reference site selection, refining regionally representative reference sites, and adding more reference sites to the survey. Consideration will be given not only

	2006	2007	2008	2009	2010	2011	2012
Lakes	Design	Field	Lab and Data Analysis	Report	Design and Planning		Field

to how alternate approaches will improve future data, but how the Agency can ensure comparability to the initial baseline.

Supplemental Reports

The NLA included data collection for several indicators for which analysis could not be completed in time for this report. These included benthic macroinvertebrates, sediment mercury, and *enterococcus*. Analysts are currently developing macroinvertebrate indicators to add to our understanding of biological integrity of lakes. Sediment mercury samples are still in the data analysis phase, as is the *enterococcus* dataset. EPA plans to produce supplements to this report with the macroinvertebrate, sediment mercury, and *enterococcus* findings. Supplemental information will be posted on http://www.epa.gov/lakessurvey.

In the next few years, EPA plans to continue additional analyses of the survey data to develop tools and strategies that will provide a better understanding of lakes and water resources in general. One important undertaking will be to conduct an in-depth analysis of the relationship between lake condition, stressors, and management actions such as point and nonpoint controls and other restoration activities. EPA plans to publish its progress and findings in interim lake survey reports.

Tools and Other Analytical Support

The next two years will also provide an opportunity for states to tailor their own statewide program to complement the national programs. Extensive discussion during the upcoming research and design phase will focus on ways to leverage and integrate national and state-scale surveys. This approach will improve the efficiency and value investment in monitoring. One EPA near-term project will be to work with the states to develop tools that can be used to re-create the survey for state-wide assessments and for customized purposes. EPA is committed to providing technical support to assist states, tribes and other partners in using these tools. Such an "assessment tool kit" might include IBI or O/E model development, habitat data analysis techniques, decision-support tools, and web-based trainings session.

Future National Assessments

EPA and its state, tribal and federal partners expect to continue to produce national assessments on a yearly cycle. Rivers and stream sampling was completed in 2008 and 2009 and a report will be released in 2011. A national coastal assessment report will be published in 2012 based on field sampling in 2010. Wetlands will be surveyed in 2011, followed by a report in 2013. In 2012, field sampling for lakes will occur again and the assessment report that follows in 2014 will include an evaluation of changes in biological condition and key stressors. Each of the water type surveys will then continue with changes and trends becoming a greater focus for each resource type.

The continued utility of these national surveys and their assessment reports depends on continued consistency in design, as well as in field, lab and assessment methods from assessment to assessment. However, the surveys should also provide the flexibility that allows the science of monitoring to improve over time. Maintaining consistency while allowing flexibility and growth will continue to be one of the challenges of the coming years.

This national lakes survey would not have been possible without the involvement of hundreds of scientists working for state, tribal, and federal agencies and universities across the nation. Future National Aquatic Resource Surveys will continue to rely on this close collaboration, open exchange of information, and the dedication, energy, and hard work of its participants. EPA will continue to work to help its partners translate the expertise they gained through these national surveys to studies of their own waters. It also will work to ensure that this valuable and substantial baseline of information be widely used to evaluate the success of efforts to protect and restore the quality of the Nation's waters.

Acronyms

ANC	Acid Neutralizing Capacity
CPL	Coastal Plains
CWA	Clean Water Act
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
GIS	Geographic Information System
IBI	Index of Biological Integrity
ITIS	Integrated Taxonomic Information System
LDCI	Lake Diatom Condition Index
NAP	Northern Appalachians
NARS	National Aquatic Resource Surveys
NES	National Eutrophication Study
NHD	National Hydrography Dataset
NLA	National Lakes Assessment
NLCD	National Land Cover Dataset
NPL	Northern Plains
O/E	Observed/Expected
ORD	Office of Research and Development, EPA
OW	Office of Water, EPA
PPR	Prairie Pothole Region
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
qPCR	Quantitative Polymerase Chain Reaction
REMAP	Regional Environmental Monitoring and Assessment Program
SAP	Southern Appalachians
SPL	Southern Plains
TIME/LTM	Temporally Integrated Monitoring of Ecosystem/Long Term Monitoring
TMDL	Total Maximum Daily Load
TPL	Temperate Plains
TN	Total Nitrogen
TP	Total Phosphorus
UMW	Upper Midwest
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WMT	Western Mountains
WQX	EPA's Water Quality Exchange
WWTP	Wastewater Treatment Plant
XER	Xeric

Glossary of Terms

Acid Neutralizing Capacity (ANC): A lake's ability to adapt to, *i.e.* neutralize, increases in acidity due to acidic deposition from anthropogenic sources (automobile exhausts, fossil fuels) and natural geologic sources.

Attributable risk: Magnitude or significance of a stressor. Is determined by combining the relative extent of a stressor (prevalence) and the relative risk of the stressor (severity).

Benthic macroinvertebrates: Benthic meaning "bottom-dwelling". Aquatic larval or adult insects, crayfish, worms and mollusks. These small creatures live on the lake bottom attached to rocks, vegetation, logs and sticks, or burrow into the sediment.

Biological assemblage: Key group or community of plant or animal being studied to learn more about the biological condition of water resources.

Biological integrity: State of being capable of supporting and maintaining a balanced community of organisms having a species composition, diversity, and functional organization.

Chlorophyll-a: A type of plant pigment present in all types of algae sometimes in direct proportion to the biomass of algae. A chemical indicator used to assess trophic condition.

Complexity: Used to describe the diversity and intricacy of an ecosystem. A complex habitat is one that has a wide range of different niches for optimum growth and reproduction for both plants and animals.

Condition: State or status of a particular indicator. For example, the biological condition of a lake is the status of a biological assemblage, such as diatoms. Often measured against a reference value or threshold.

Ecoregions: Ecological regions that are similar in climate, vegetation, soil type, and geology; water resources within a particular ecoregion have similar natural characteristics and similar responses to stressors.

Epilimnion: The uppermost, warmest, well-mixed layer of a lake during summertime.

Euphotic zone: The uppermost layer of the lake defined as the depth at which light penetrates.

Eutrophic: See Trophic state.

Eutrophication: The process of increased productivity of a lake or reservoir as it ages. Often this process is greatly accelerated by human influences and is termed cultural eutrophication.

Hypereutrophic: See Trophic state.

Hypolimnion: The lower, cooler layer of lake during the summer.

Lakes Diatom Condition Index (LDCI): The sum of individual measures of a diatom assemblage, such as number and composition of taxa present, diversity, morphology, and other characteristics of the organisms.

Limnological: Of or pertaining to the study of fresh waters.

Littoral zone: The water's edge. The lake bottom extending from the shoreline lakeward to the greatest depth occupied by rooted plants.

Macrophyte: Literally meaning "large plant." An aquatic plant that can grow emergent, submergent or floating.

Mesotrophic: See Trophic state.

National Hydrography Dataset: Comprehensive set of digital spatial data that contains information on surface water features across the U.S.

Nutrients: In the context of the NLA, substances such as nitrogen and phosphorus that are essential to life but in excess can overstimulate the growth of algae and other plants in aquatic environments. Excess nutrient can come from agricultural and urban runoff, leaking septic systems, sewage discharges and similar sources.

O/E (Observed/Expected) Ratio of Taxa Loss: A comparison of the number of taxa that are observed (O) at a site relative to the number of taxa expected (E) to exist for a site of similar nature. The taxa expected at individual sites are based on models developed from data collected at reference sites.

Oligotrophic: See Trophic state.

Pelagic zone: The open area of a lake, from the edge of the littoral zone to the center of the lake.

Primary productivity: The production of organic compounds from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis. All life on earth is directly or indirectly reliant on primary production. In aquatic ecosystems, the organisms responsible for primary production are the phytoplankton, and form the base of the food chain.

Probability-based design: A type of random sampling technique in which every site in the population has a known probability of being selected for sampling. Results from the sampled sites can be used to represent the population as a whole.

Profundal zone: The deepest part of the lake. The lake bottom located below the depth of light penetration.

Reference condition: The least-disturbed condition available in an ecological region, determined based on specific criteria, and used as the benchmark for comparison with the surveyed sample sites in the region.

Regionally-specific reference: A subset of the reference condition based on reference lake sites of similar type and geography. For ecoregional assessments, the lakes are only compared to the particular reference lakes that are similar for that area.

Relative extent: The relative prevalence of a specified condition (such as poor) for a stressor or biological indicator. A stressor with a high relative extent means that it is relatively widespread when compared to other stressors.

Relative risk: The severity of the stressor. Like attributable risk and relative extent of the risk, this term is used to characterize and quantify the relative importance of the stressor. Stressors with low relative extent and high relative risk are called "hot spots".

Riparian zone: The banks or shoreline of a lake or waterbody.

Riparian or Shoreline disturbance: A measure of the evidence of human activities alongside lakes, such as roadways, dams, docks, marinas, crops, *etc.*

Riparian vegetative cover: Vegetation alongside lakeshore. Intact riparian vegetative cover reduces pollution runoff, prevents streambank erosion, and provide shade, food, and habitat for fish and other aquatic organisms.

Secchi transparency: A measure of the clarity of water obtained by lowering a black and white, or all white, disk (Secchi disk) into the water until it is no longer visible. Measured in feet or meters.

Stressors: Factors that adversely affect, and therefore degrade, aquatic ecosystems. Stressors may be chemical (*e.g*., excess nutrient, pesticides, metals), physical (*e.g*., pH, turbidity, habitat), or biological (*e.g*., invasive species, algal bloom).

Stressor-response: Change in biological condition due to the presence of one or more stressors.

Sublittoral zone: The lake bottom area between the littoral (rooted plants) to the depth at which there is no more light penetration.

Taxa: Taxonomic grouping of living organisms, such as family, genus or species, used for identification and classification purposes. Biologists describe and organize organisms into taxa in order to better identify and understand them.

Threshold: The quantitative limit or boundary. For example, an assessment threshold is the particular percentage of the reference condition or cut-off point at which a condition is considered good, fair or poor.

Trophic state: Meaning "nourishment." Used to describe the level of productivity of a lake.

> *Oligotrophic:* A nutrient poor lake. Describes a lake of low biological productivity and high transparency or clarity.
>
> *Mesotrophic:* A lake that is moderately productive.
>
> *Eutrophic:* A well-nourished lake, very productive and supports a balanced and diverse array of organisms. Usually low transparency due to high algae and chlorophyll-*a* content.
>
> *Hypereutrophic:* Characterized by an excess of nutrients. These lakes usually support algal blooms, vegetative overgrowth, and low biodiversity.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central repository such as a lake, river or the ocean.

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